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Stuart G. Hibben

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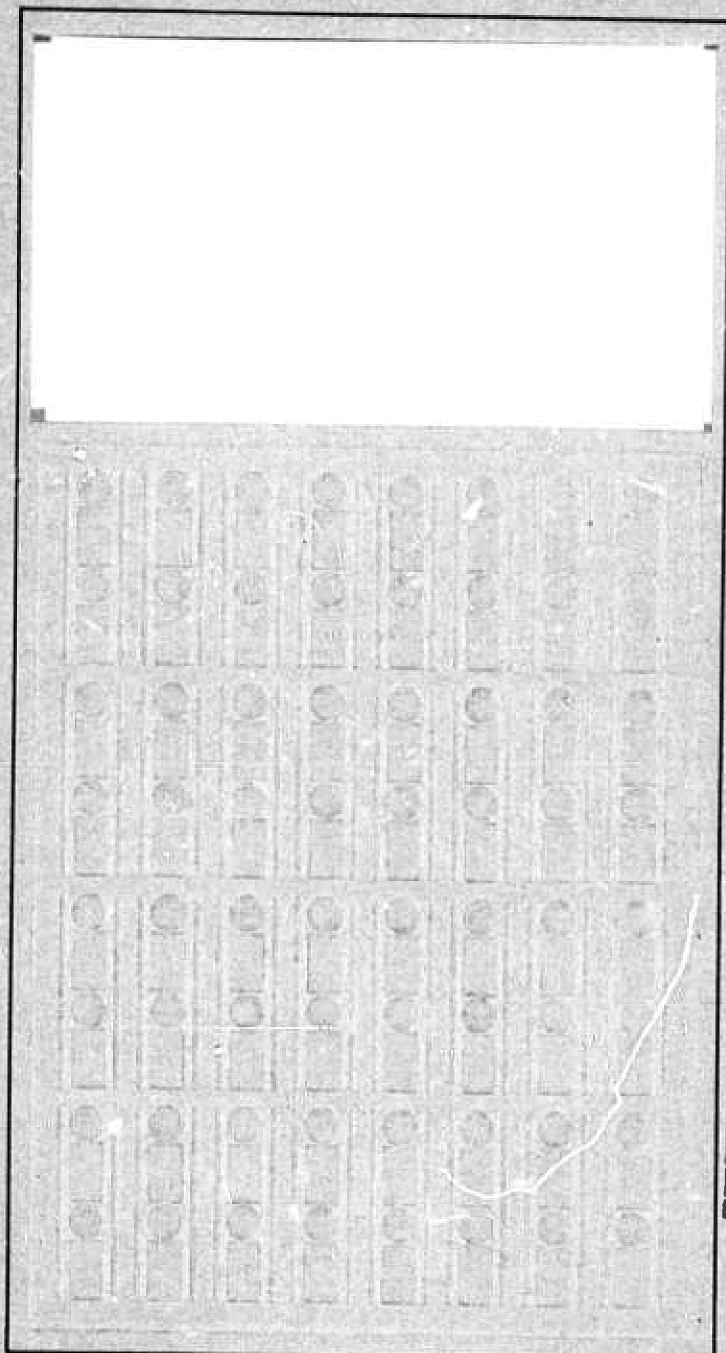

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13. ABSTRACT

This report includes abstracts and bibliographic lists on contractual subjects that were completed in January, 1973. The major topics are: laser technology, effects of strong explosions, geosciences, particle beams, and material sciences. A section on atmospheric physics and one on items of miscellaneous interest are included as optional topics.

Laser coverage is generally limited to high power effects; all current laser material is routinely entered in the quarterly laser bibliographies.

An index identifying source abbreviations and a first-author index to the abstracts are appended.

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TABLE OF CONTENTS

1. Laser Techology

A. Abstracts

Golodenko, N. N., and V. M. Kuz'michev. Thermal processes in metals irradiated by high-power pulsed lasers. TVT, no. 5, 1972, 1126-1129.

A brief theoretical treatment is given of thermal conductivity parameters in the impact zone of a laser-irradiated metal target. The case is idealized to an unbounded plane target surface, subjected to constant energy density laser pulses. The actual effect of finite beam diameter and resultant outflow of heat along the target surface can be neglected as long as pulse length $\tau << r_o^2/a$, where r_o = beam radius at impact and a = thermal conductivity coefficient; this applies in the assumed model of a Cu target and an unfocused laser pulse of the order of $1\mu s$ or less. Laser energy absorption in the vapor products for this model is shown to be less than 1% and can also be neglected.

Surface heating parameters as functions of τ, energy density and vapor layer depth are presented graphically, based on the analytical expressions derived by the authors. Fig. 1 shows the fraction of energy incident on the metal surface with varying pulse shape, width and density. Fig. 2 gives depth of evaporated layer vs. pulse parameters. Fig. 3 and 4 show surface heating dynamics, and Fig. 5 compares absorbed power density to density at the metal surface. The latter solution illustrates the appreciable difference between the characteristics of total delivered and actual surface power densities.

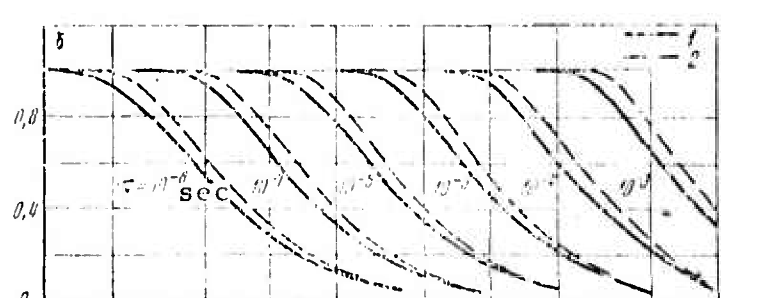

Fig. 1. Fraction of energy δ incident on metal surface vs. energy density and τ. 1 - bell-shaped pulse; 2 - rectangular pulse.

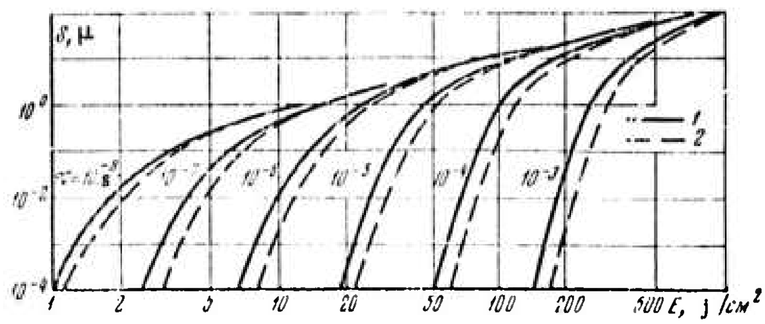

Fig. 2. Depth of vapor layer vs τ and energy density. 1, 2 - as in Fig. 1.

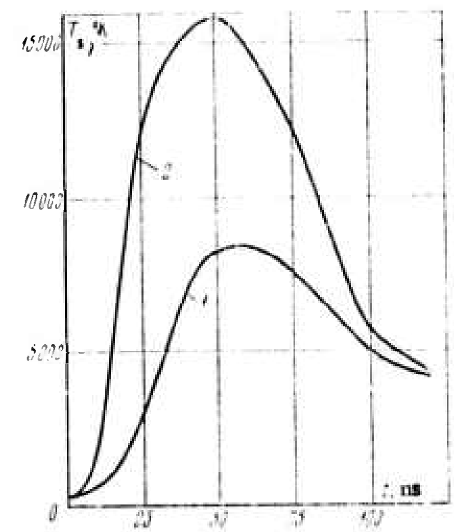

Fig. 3. Surface temperature vs. time, bell-shaped pulse, τ = 100 ns. 1 - 10 j/cm^2; 2 - 60 j/cm^2.

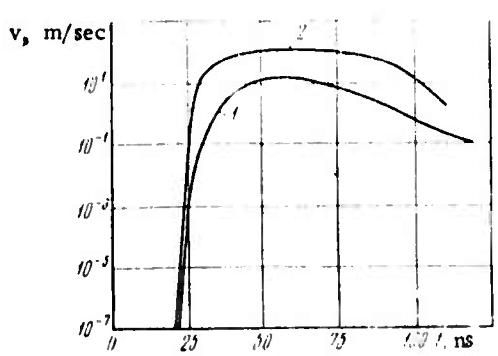

Fig. 4. Surface vaporization rate vs. time. Pulse parameters as in Fig. 3.

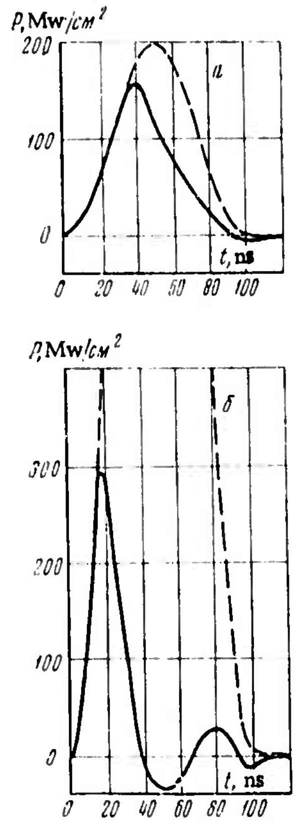

Fig. 5. Surface energy density vs. time. a - 10 j/cm^2; b - 60 j/cm^2. Dashed line is total delivered, solid line is actual surface density.

Orlov, A. A., and P. I. Ulyakov. Development of internal destruction in silica glasses and polymers from laser radiation. ZhPMTF, no. 4, 1972, 138-145.

The role of light pulses in the process of internal destruction was investigated on polymethylmethacrylate (PMMA) and type K-8 and F-5 silica glass, using a laser (λ = 10.6 μ) operating in a spike mode. The specimen length was 20-30 mm. The pulse-averaged threshold energy density $<\epsilon_o>$ was ~15 joule/cm^2. The process of destruction was recorded on film, and the energy E^* passing through the specimen at the initial stage of the process was also recorded. Experimental points of the dependence t^* on $q^* = E^*/t^*S$, where S is the area of the focused spot appear to contradict the previous assumption that the destruction process is determined solely by the amount of absorbed energy independent of flux density. The corresponding hyperbolic dependence $t_o = <\epsilon_o>/q$ is lower by at least one order than the t^* values obtained experimentally. The research is based on recent studies of the kinetics of destruction processes in PMMA polymers showing that a high-temperature cavity center is formed in the material, at the initial stage filled with products of evaporation and decomposition of the polymer. Radiation absorption in the center raises the internal pressure, which leads to increased stresses and to crack formation. The authors derived a model and established a relationship between the total irradiation time preceding destruction, t^*, and the average power density q^*. Results of calculations for PMMA using a given formula agree satisfactorily with experimental data.

The destruction process in glass differed substantially from that in PMMA. At a time interval t^* from the onset of irradiation, an extended, brightly illuminated zone was formed in the focal region in a direction toward the beam. Since the experimental curves $t^*(q^*)$ fall below the hyperbolic dependence $t = <\epsilon_o>/q$, it follows that glass destruction sets in before the threshold energy density $<\epsilon_o>$ is reached. This density is averaged over the total pulse duration. The wide spread of points on the given graphs is due to strong variations in the local glass strength. The authors use a damage center model in glass at fluxes less than 10^{10} w/cm^2 to analyze the micro-flaws formed owing to light absorption. These flaws are the result of electron photo-impact ionization when an increase of concentration n_e leads to a slight nonlinear absorption increase and increased temperature and vaporization o of material. Subsequent rapid increases of temperature and pressure in the center cause the destruction of the adjacent material. The center formation relationship for t^* (q^*) was obtained, which adequately describes the experimental graphs.

Stoyanova, I. G., A. A. Timofeyev, A. V. Antipova, G. G. Levadnyy, and A. N. Zelyanina. Electron microscopic study of pore formation in thin resistive films from coherent radiation. IAN Fiz, no. 9, 1972, 1937-1944.

Structural changes in films from pore formation under high-intensity ultraviolet radiation are studied, including the effects of powerful coherent radiation and the pulse count on the processing of thin resistive films. A pulsed nitrogen laser (λ = 3371 Å; pulse power - to 10^4 w; pulse duration - 10^{-8} sec; and pulse repetition rate - to 150 Hz) was used. These parameters minimized post-pulse effects while permitting a pulse density up to 10^9 w/cm^2 at spot center. Cermet (Cr-SiO) or type MLT-3M metal (Cr-Si-Fe-W) thin film specimens were used which absorbed up to 30-40 percent of incident u-v energy. Electron optical analysis results reported earlier by the authors (Sbornik. Ispol'zovaniye opticheskikh kvantovykh generatov v sovremennoy tekhnike, Part 1, Leningrad, 1971, 14) show that thin resistive films irradiated by laser beams undergo structural changes and an area with a modified structure is formed on the boundary where vaporization occurs. The first pulse caused the material to melt and recrystallize in the irradiated zone, the second pulse induced vaporization in the zone exposed to the first pulse. Drops of melted material subsequently appeared accompanied by the formation of a pore of about 1 μ in diameter (Fig. 1). At an increased pulse count of the same intensity the pore expanded to a maximum diameter under the given conditions. Further increases in pulses introduced no significant variation in the irradiation pattern. At low radiation intensities, using single pulses and narrowly-focused laser beams it is possible to generate smaller diameter pores. Laser ultraviolet processing of thin resistive films produces 1μ pores when d/l ratio (hole diameter to the modified structure zone width) is about 10.

At very high radiation intensities the full process may be complete using a single pulse, yielding a modified structure zone width smaller than the hole diameter. The d/l ratio may reach 100. Structural failure of materials in th irradiation zone is minimal, with no large-size crystal formation. The material is finely separated and the particle size is similar to the initial form of the material. At large intensities, the hole diameter is no larger than the focused beam diameter.

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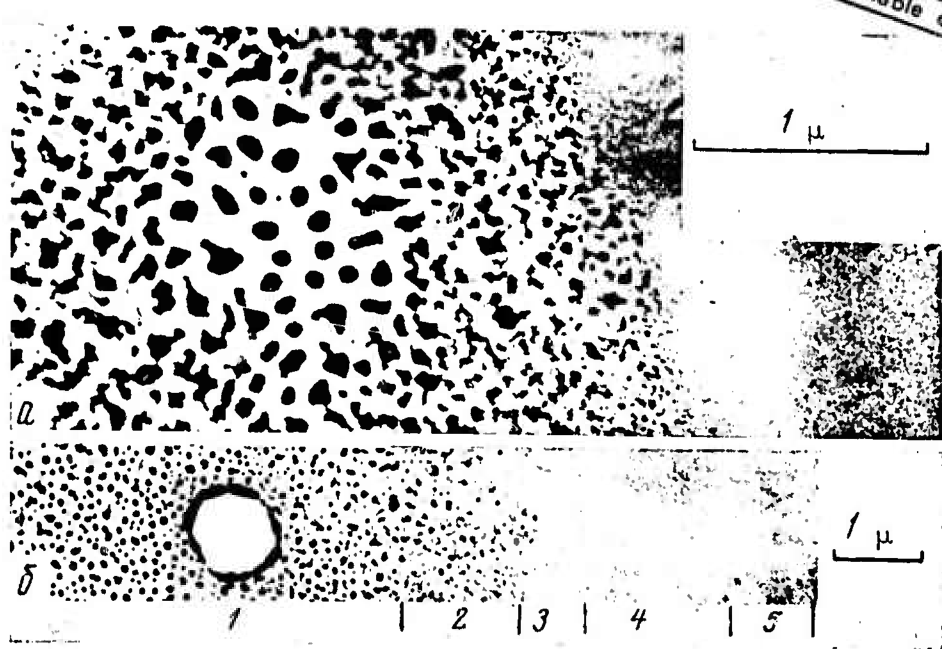

Fig. 1. Electron-microscopic image of a 100 Å thick resistive film under the impact of a single pulse (a) and two pulses (b) of equal intensity W. The crystal size of the specimen illustrated in Fig. 1 is maximum on the boundary of the processed area and may amount to 400 Å. Crystal compositions were Cr, Cr_2O_3 and SiO.

Golubets, V. M., M. I. Moysa, Yu. I. Babey, and G. V. Plyatsko. Effect of laser processing on part wear in an abrasive-oily medium. F-KhMM, no. 4, 1972, 114-115.

Studies on the effects of processing of steel and cast-iron specimens by a laser beam for wear in an abrasive-oily medium are presented. A neodymium laser beam, with an energy of 70 joules at a pulse duration of about 4 milliseconds, 1.5 pulses per minute, was focused on an area about 3.5 mm in diameter. The experiments showed that acute changes of the structur and of the physicomechanical properties of the metal take place in the surface layers of the specimens. In the treated areas a white layer originates which, after polishing of the specimens, measured 1,000 microns thick for 40 Kh steel in a hardened and low-tempered state, 420 microns for 40 Kh steel in a normalized state, and 440 microns in high-strength cast iron. The microhardness of the white layer is about three times greater than that of steel after normalization, more than twice as great as that of high-strength cast iron, and about 16% greater than that of the martensite of hardened steel. Tests showed that laser processing which brings about the indicated surface layer changes increases the wear resistance of friction pairs in an abrasive medium. Wear of 40 Kh steel in a normalized state with the white layer decreased by a factor of about 3 in comparison to a polished surface without the white layer, and for hardened and low-tempered 40 Kh steel the wear decreased correspondin by a factor of about 2, as did also wear of high-strength cast iron.

Akulenok, Ye. M., Yu. K. Danileyko, A. A. Manenkov, V. S. Nechitaylo, A. D. Piskun, and V. Ya. Khaimov-Mal'kov. Mechanism of laser beam damage of ruby crystals. ZhETF P, v. 16, no. 6, 1972, 336-339.

This is a study of the effects of various admixtures upon the internal destruction threshold of ruby and sapphire crystals, grown by the Verneuil method and doped with titanium, vanadium, iron, cobalt, nickel or magnesium in concentrations ranging from 10^{-3} to 10^{-4} percent. Depending on the conditions of growth and on the subsequent heating of crystals, these dopants can change valence and form extraneous phase inclusions. The valence state of these dopants which are isomorphs in the lattice was determined in several ways: a) optical absorption and luminescence spectra; b) ultramicroscopy in scattered light to determine the presence of extraneous inclusions, a method which established the particle size at $a \gtrsim 3 \times 10^{-6}$ cm; c) microscopic x-ray phase analysis of emerging particles. Investigations have also shown that valence conversions of dopants and extraneous phase precipitation are fully reversible when the annealing atmosphere is changed. Table I shows the results of measurements under the impact of ruby laser emission with giant pulses (τ = 40 nanosec) and under multimode conditions, indicating the relative destruction threshold P_d of the doped specimens; $P_d^o \cong 2 \times 10^{10}$ watt/cm^2 is the threshold of internal destruction for a control specimen containing no dopants. The results are equally applicable to ruby and sapphire crystals.

Table I. Relative damage threshold P_d/P_d^o for doped sapphire.

Anneal atmosphere \ Dopant	Ti	V	Co	Ni	Fe	Mg
Oxygen	$3 \cdot 10^{-2}$	$5 \cdot 10^{-2}$	0,5	0,6	0,6	$6 \cdot 10^{-2}$
Vacuum	0,8	$7 \cdot 10^{-2}$	10^{-2}	$2 \cdot 10^{-2}$	10^{-2}	0,9

Analysis of the results shows that in cases when new phases appear in the sapphire crystals a drastic reduction (up to 50 times) of internal destruction thresholds is observed. Where there are no foreign inclusions, all ruby and sapphire specimens show no substantial difference in P_d values, irrespective of the type of dopants added or of their valence states. This is due to the presence of uncontrollable inclusions of the extraneous phase; noticeable Rayleigh scattering, measured by the authors, attests to the presence of such phases. It is concluded that the mechanism of destruction of real crystals is evidently related to the presence of absorbing inclusions, an observation which thus far has remained unnoticed in the literature.

Norinskiy, L. V. <u>Investigation of optically triggered controlled electric breakdown in gas.</u> Sixth All-Union Conference on Linear Optics, Minsk, 1972. (Preprint)

The mechanism of controlled electrical breakdown, triggered by collimated intensive ultraviolet radiation with 3.5 ev quantum energy in air, was experimentally investigated. Two possible triggering mechanisms are assumed. Results of experiments are given in which the effect of different fields (high-frequency, optical, pulsing and c-w) was separated into time intervals, to obtain a more accurate picture of the mechanism. It is demonstrat that controlled breakdown occurs from the simultaneous effects of electrical and optical fields when their pulses overlap in time. This suggests the existence of a triple electron-photon-atom interacting mechanism for ionizing gas molecules.

Alekseyev, V. A., A. Ya. Balagurov, N. P. Kozlov, L. V. Leskov, Yu. S. Protasov, and V. I. Khvesyuk. Plasma focus as a source of laser pumping. Sixth All-Union Conference on Nonlinear Optics, Minsk, 1972 (Preprint).

It is reported that under certain conditions, pulsed erosion-type plasma accelerators, operating continuously with metal and dielectric plasma, can produce stable quasi-stationary self-burning plasma fluxes with a velocity of $\sim 10^7$ cm/sec, temperature of 5 ev, and particle concentration $\sim 5 \times 10^{18}$ cm^{-3} in a vacuum of $\sim 10^{-6}$ torr pressure. Tests are described in which the size and dynamics of the compressed zone were determined by ultrahighspeed and shadow photography. Some 0.8 cm away from the electrode section the flux jet was first compressed to 0.5 cm over a distance of 4 cm, and then dispersed with an apex angle of $\sim 25^{\circ}$. The focus interval is 10 to 100 microsec; luminous flux rise time is 4 to 10 microsec. Investigation of particle density shows that the degree of flux compression reaches 100; 80% of the plasma passes through the focus zone. The plasma spectrum was investigated over the 2000-6000 A ran[illegible] In addition to a broadened line spectrum there were considerable portions of continuous spectrum.

Electron temperature, determined from relative intensities, was about 3.5 ev. Investigation of the time dependence of temperature with respect to self-reversal of spectral lines shows that at the moment of maximum compression the temperature reaches ~ 5 ev. Radiant energy in the region of 50-2000 A was measured by three-layer bismuth bolometers with a resolving time of 1 microsec, placed inside and outside the accelerators. In the region above 2000 A (black bolometer) the recorded radiant energy showed a 20-25% increase. The portion below 1180 A amounted to ~ 45% of the total energy of radiation. The presence of a hard component of radiation (under 100 A) was detected, recorded by a photosensor with absorbing foils. When operating with metal plasma, the radiant energy increases 40-50% as compared to a fluorine-carbon plasma. In this mode the radiant energy amounts to 4-16% of energy stored in condensers.

The experiment verifies that self-focusing of a plasma jet and the high radiant energy limit permit it to be used for generating light flashes of short duration with an increased yield of ultraviolet radiation and higher energy, for optical pumping of active laser media, e.g. in pulsed photolysis, etc. Proper selection of the working medium and accelerator parameters for the generation of focused light flashes makes it possible to obtain flashes of desired duration, pulse shape, and the proper size and spectral distribution of luminous energy. A plasma focus was used in this way to obtain laser emission from an alcohol solution of rhodamine 6 G. The ID of the working cell was 3 mm, its length - 90 mm. An aqueous solution of sodium acetate was used for filtering. The resonator was formed by external flat mirrors with reflection coefficients of 99 and 60%. An emission energy of 0.22 j and radiation intensity of 0.15 milliwatt was achieved.

Aglitskiy, E. V., N. G. Basov, V. A. Boyko, V. A. Gribkov, S. A. Zakharov, O. N. Krokhin, and G. V. Sklizkov. Determination of electron density, velocity and gas-dynamic pressure in laser plasma. 10th Int. Conf. Phenomena Ioniz. Gases, Oxford, 1971. Contrib. pap. Oxford, 1971, 229. (RZhMekh, 8/72, no. 8B193)(Translation)

An experimental determination is made of the electron concentration N_e, the expansion velocity, and the gas dynamic pressure in the dense hot region of plasma formed by the laser irradiation of a carbon target. The profile of N_e is determined on the basis of measurement of the Stark spectral line broadening of hydrogen-like ions, and the time evolution of this profile is determined by means of a high-speed interferometric procedure. The expansion velocity V of the plasma was evaluated on the basis of time scanning of the spectral lines (in the visible spectrum region), and on the basis of the Doppler shift of the resonance-absorption lines which takes place in the expanding (colder) plasma shell. The measured values of N_e and V make it possible to determine the time evolution of the gas-dynamic pressure p of plasma in the hot region. An interesting feature is the nonmonotonic time change of p. The presence of the peak of p is linked to the shielding of laser radiation by peripheral regions of the plasma, and makes it possible to explain the presence, noted by other authors, of a temperature peak at the initial stage of laser heating.

Zaroslov, D. Yu., Ye. K. Karlova, N. V. Karlov, G. P. Kuz'min, and A. M. Prokhorov. Plasma jet CO_2 laser. ZhETF P, v. 15, no. 11, 1972, 665-668.

Plasmatron excitation of a CO_2 laser is reported for the first time; it was accomplished by injecting plasma jets, formed in capillary plasmatrons, into the operating volume of the laser. The experiment was carried out in a laser system with transverse excitation; the split cathodes of the system were replaced with a row of 25 capillary plasmatrons with simultaneous injection of plasma flares into the laser. Each capillary was 5 mm long, 1 mm in diameter and spaced 1 cm apart. A mixture of CO_2 + N_2 + He with the ratio of components being 1:2:3, respectively, was tested at a pressure of 30 torr. A voltage of up to 10 kv was supplied to the discharge gap of the working volume, the gap being 2 cm in length. Intensive generation was produced when voltage was applied simultaneously to capillaries and electrodes. Generation energy reached 0.1 joule. The generated pulse had an intensive spike at the leading edge with 0.1 microsec duration.

Dependence of generation energy on electrode voltage is shown in Fig. 1, where U_1 is voltage on the capillary, U_2 - on the electrodes of the working volume.

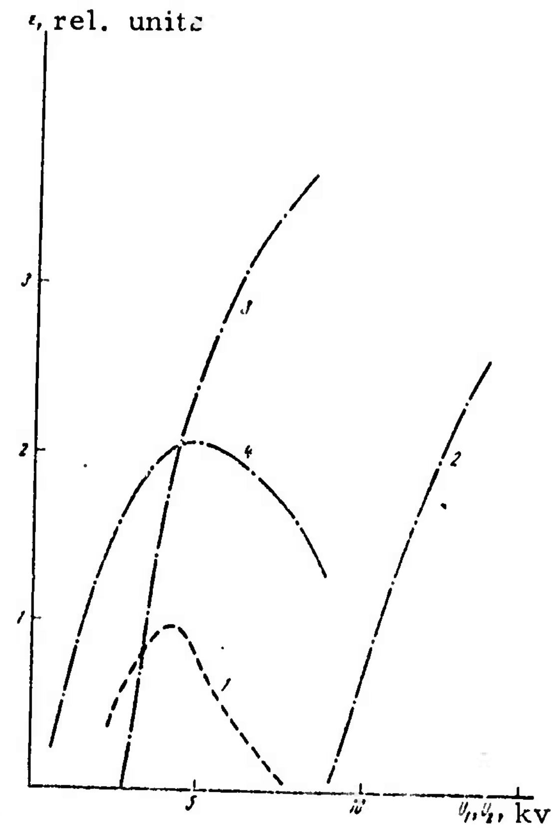

Fig. 1. Relative emission energy vs. electrode voltage. 1 - $U_1 = 0$; 2 - $U_2 = 1$ kv; 3 - $U_2 = 2$ kv; 4 - $U_2 = 2.5$ kv.

Under optimal conditions the voltage on the electrodes was 2 kv; this is not enough to obtain a gas breakdown in the working volume of the laser and to produce a generation in the absence of plasma jets in the volume. A marked increase in generation energy occurs only as a result of the joint effect of plasma jets and of the accelerated voltage in the working volume, i.e. when the pulses exciting the working volume and the capillaries are carefully synchronized. Increased energy input into the capillaries also permits operation at higher pressures.

Bykovskiy, Yu. A., N. M. Vasil'yev, N. N. Degtyarenko, V. F. Yelesin, I. D. Laptev and V. N. Nevolin. Form of the ion energy spectrum in a laser plasma. ZhETF P, v. 15, no. 6, 1972, 308-311.

A laser plasma consisting of two components, one of singly-charged ions and the other from multi-charged ions, was studied. Particular attention was paid to the energetic distribution of ions of hydrogen and zirconium (zirconium hydride) and deuterium and lithium (LiD) at different flux densities q. Fig. 1. shows results obtained for a ZrH target. H^+ and D^+ ions were found to have one and the same maximum. Its position does not depend on the q value, and occurs at 100± 10 ev.

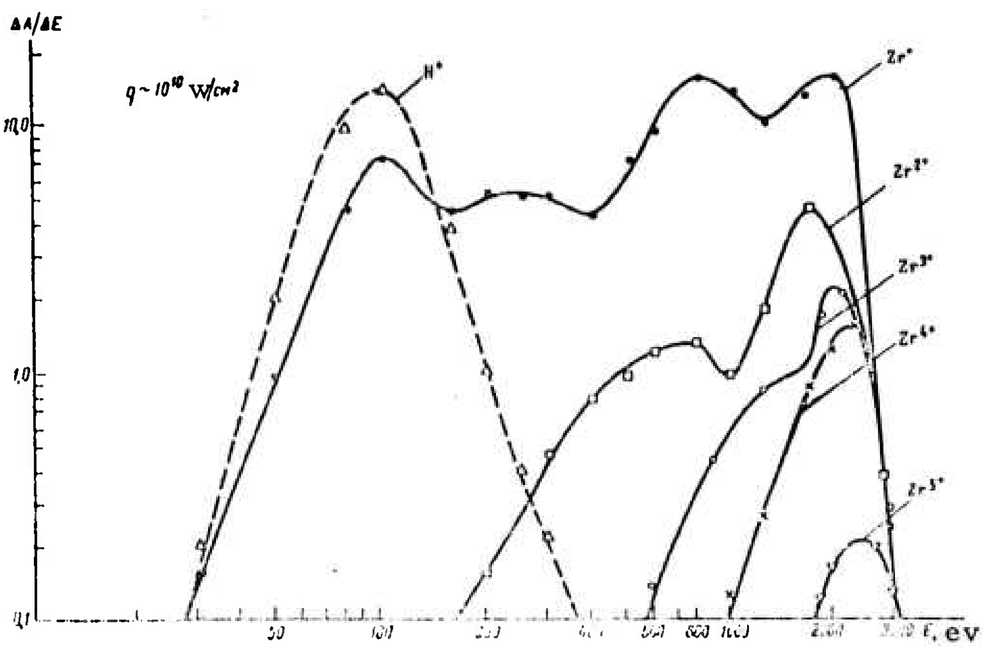

Fig. 1. Ion energy spectrum from laser-irradiated ZrH target.

The following relationships were measured: a) $E_{max} = f(q)$ for ions of hydrogen, deuterium, lithium, and zirconium. The relationship can be described by $E_{max} \sim q^{\gamma}$; with this expression the value of γ for H and D is 0.25 ± 0.03, whereas for Li and Zr, $\gamma = 0.52 \pm 0.05$. Here E_{max} is the maximum kinetic energy of ions accelerated by a self-consistent electrostatic field formed at the periphery of the bunch. b) Dependence of the number of recorded ions Σ on the q value. This dependence is expressed in the form of $\Sigma \sim q^{a}$; for D the a value $= 0.8 \pm 0.1$, and for Li a $= 1.1 \pm 0.1$. The established relations depend strongly on z_{max} and only slightly on the ion mass, which serves as evidence for the effect of the electrostatic field in plasma on the scattering of recorded ion particles.

The relation of maximum velocities of ions of all elements comprising the target was also studied. It was shown that H^+ and D^+ ions overtake the ions of the heavier elements bearing the same charge. Hence at $q \cong 10^{11}$ watt/cm^2,

$$v^{H}_{max} / v^{Zr}_{max} \approx 3{,}1 \, [z_{max}(Zr) = 6], \quad v^{D}_{max} / v^{Li}_{max} \approx 1 \, [z_{max}(Li) = 3].$$

Estimates of the absolute number of plasma-emitted ions show that at $q \cong 10^{11}$ watt/cm^2, $N_{emit} \approx 10^{11}$ particles; at this value of q the number of vaporized atoms $N \cong 10^{16}$. The ratio of accelerated ions to the total number of ions, i.e. $N_{acc}/N_{tot} \cong 10^{-4} - 10^{-5}$. Consequently, in later stages of plasma dispersion only accelerated ions are registered, while the main portion of ions moves along with thermal velocities and is subject to recombination.

Rysakov, V. M., and V. I. Korotkov. Study of the intensity of stimulated Brillouin scattering in glass. FTT, no. 7, 1972, 1896-1900.

The intensity of stimulated Brillouin scattering in glass was investigated using a ruby laser (Fig. 1). The single-stage laser was Q-switched by a revolving prism and operated in axial or transverse modes at a power of 5 M

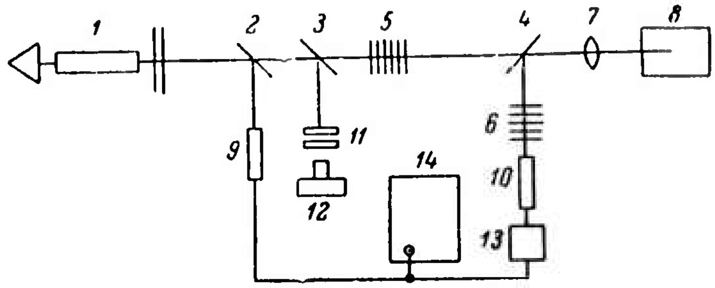

Fig. 1. Experimental block diagram.
1 - ruby laser, 2, 3, 4 - light dividers,
5, 6 - calibrated attenuators, 7 - lens,
8 - specimen, 9, 10 - photomultipliers,
11 - Fabry-Perot interferometer,
12 - long-focus objective camera, 13 -
delay line; 14 - scope.

pulse duration of 70 nsec; and a bandwidth of ~ 0.02 cm^{-1}. The specimens were fused quartz, standard K-8 glass, and plexiglas. The intensity of the exciting beam I_o was varied by calibrated neutral filters. Signals were recorded photoelectrically by an apparatus which accurately registered the stimulated Brillouin scattering component power variations. Power relations of the scattering components were determined as functions of excitation power (Fig. 2), lens focal length, and beam dispersion. Measured amplification factor g for the specimens were: $(1.1 \pm 0.4) x 10^2$, $(1.1 \pm 0.4) x 10^2$ and $(1.5 \pm 0.6) x 10^2$ cm/Mw for quartz, K-8 and plexiglas, respectively. The experimental g value for quartz glass was similar to the calculated value, confirming the theory of stimulated Brillouin scattering developed by Kroll and Tang. The self-focusing effect on the amplification coefficient of stimulated Brillouin scattering due to electrostriction is discussed. The estimated hypersonic attenuation coefficients were ~ 400 in K-8 and ~ 2100 cm^{-1} in plexiglas.

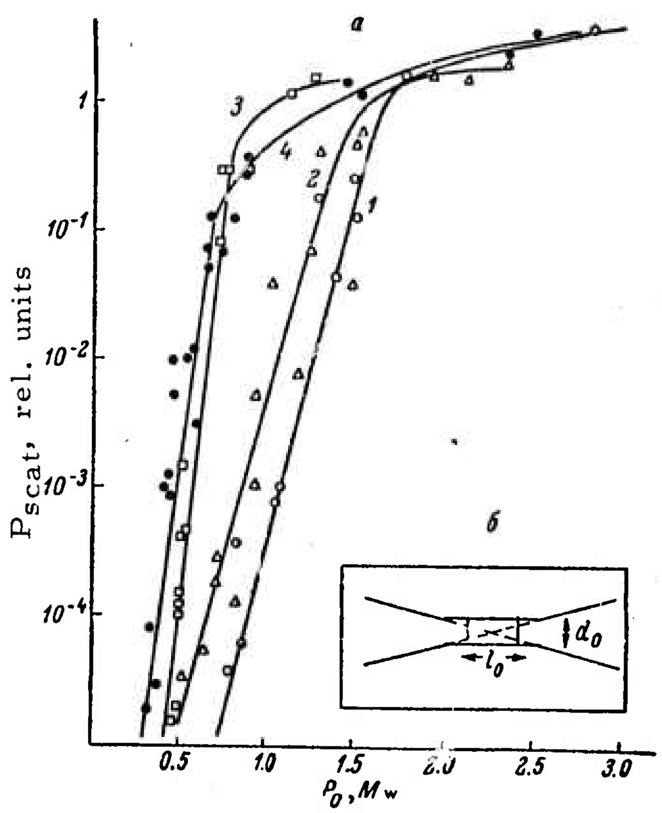

Fig. 2

a. Power relationship of stimulated Brillouin scattering components to excitation power (relative units); 1 - quartz glass, $\vartheta = 6x10^{-4}$, F = 9 cm; 2, 5 - K-8, $\vartheta = 5x10^{-4}$, F = 5 cm; 3 - K-8, $\vartheta = 7x10^{-4}$, F = 22 cm; 4 - plexiglas, $\vartheta = 5x10^{-4}$, F = 5 cm).
b. Approximate beam cross-section near the lens focus, used for the calculations.

Askar'yan, G. A., Kh. A. Diyanov, and A. Mukhamadzhanov. Eliminating self-collapse of a high power beam in a nonlinear medium by means of a grid - a multiple waveguide propagation of energy. Diffraction grating in a nonlinear medium. ZhETF P, v. 16, no. 4, 1972, 211-215.

Experiments are described which show that it is possible to eliminate self-focusing of a high power beam in a nonlinear medium by interposing a fine-mesh grid, which gives the effect of multiple waveguide propagation. A Q-switched Nd glass laser was used with 10^6 w pulse power, passed through a vessel filled with nitrobenzene which had a nominal self-focus threshold $P_{thr} \cong 100$ kw for a 2 mm diameter incident beam. The nomimal self-focus point was observed by sparks in the liquid at points of maxim[um] energy density, which in the absence of the grid occurred at a beam penetration of 3 cm into the liquid. By interposing a grid with 1.5--3×10^{-2} cm mesh and 50-60% transmissibility between the laser source and the vessel input face, the distance to the sparking point could be increased to 26 cm; in this case sparking could be observed over the entire beam cross-section. Analysis of the effect shows that both transverse energy gradients and angles of divergence are determinants in self-focusing.

The article goes on to examine the problem of diffraction scattering in a nonlinear medium. For a given radial distribution of energy densi[ty] it is possible to select a grid mesh such that each element receives energy close to threshold; at the same time the transverse gradient of the sub-beam would be weakened by diffraction, hence its scattering and deflection would also decrease.

Splitting of the beam by the cited grid method for preventing its collapse has advantages over other methods, such as increasing beam divergence by means of a lens. The latter method, because of small gradient of angular spacing of sub-beams, cannot prevent a collapse whenever the beam power is above the threshold value.

Andriyakhin, V. M., Ye. P. Velikhov, V. V. Vasil'tsov, S. S. Krasil'nikov, V. D. Pis'mennyy, I. V. Novobrantsev, A. T. Rakhimov, A. N. Starostin, and V. Ye. Khvostionov. High-pressure gas laser with preionization by a reactor. ZhETF P, v. 15, no. 11, 1972, 637-639.

Experimental combination excitation of a CO_2 laser is described. A nuclear reactor was used as a source of gas ionization; flux density of thermal neutrons in the central channel $\Pi \cong 5 \times 10^{16}$ n/cm^2/sec^1, pulse duration $\cong$ 1 millisec. The laser was in the form of a plastic cylindrical tube with an inside diameter of 37 mm and a length of 550 mm; two dural electrodes were placed in parallel in the tube with electrode surface $S = 500 \times 20$ mm^2 and the spacing between surfaces 15 mm.

The tube was placed in the central reactor channel and charged wit a $CO_2 + N_2 + He^3$ mixture. The total pressure of all components was 2.5 atm (CO_2 - 0.8 atm; N_2 - 0.7 atm; He^3 - 1 atm). The high conductivity of the interelectrode gap was caused by ionization losses of charged products of nuclear emission He^3 (n, p)H^3 + 0.8 Mev. Laser energy per pulse was about 1 joule. An oscillogram of the discharge current during the reactor operation is shown in Fig. 1.

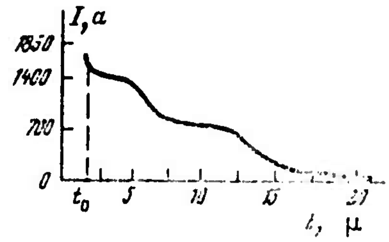

Fig. 1. Current pulse form.
Peak prior to t_o omitted because
of scope dead time.

Theoretical estimates for the conductivity σ of the gas discharge plasma were made; the value obtained was $\sigma \approx 10^9$ CGSE units. This value was derived from the balance of electrons generated in gas during proton retardation. The authors conclude that their estimates agree satisfactorily with the experimental time dependence of the current, and accurately reflect the spatial character of discharge combustion during generation. Generation occurred during the heating of gas, the duration of which was $\tau_T = \omega/\sigma E^2$, and was on the order of several microseconds, where ω is the specific enthalpy. This period is larger than $\tau_T = L/R$, where L is the inductance of the electric circuit and R is the active resistance of the gas-discharge gap.

B. Recent Selections

i. Beam Target Effects

Betaneli, A. I., L. P. Danilenko, T. N. Loladze, Ye. F. Semiletova, B. M. Zhiryakov, and A. K. Fannibo. Feasibility of supplementary alloying of type R-18 steel surfaces by laser beam. FiKhOM, no. 6, 1972, 22-26.

Fonkich, M. Ye., I. S. Lutsik, B. T. Piven', and M. V. Sidenko. Effect of longwave laser irradiation on latent images. ZhNiPFiK, no. 6, 1972, 465-467.

Golodenko, N. N., and V. M. Kuz'michev. Pulsed laser heating and vaporization of metals. Radiotekhnika, Khar'khov, no. 23, 1972, 139-142.

Rykalin, N. N., A. A. Uglov, and A. N. Kokora. Effect of laser irradiation of iron alloys. FiKhOM, no. 6, 1972, 14-21.

Shestakov, A. I., and V. S. Orlova. Lazernaya svarka mikrodetaley (Laser welding of microcomponents). Leningrad, Izd-vo Znaniye, 1972, 19 p. (LC/VKP)

Velichko, O. A., V. G. Yemel'yanov, and V. P. Zhdanov. Laser welding of anode and cathode junctions in tubes. Avtomaticheskaya svarka, no. 7, 1972, 70. (LZhS, 50/72, no. 168101)

Yygi, Kh. R.-V., and A. F. Malysheva. Electron microscope and optical analyses of ultraviolet irradiated KBr crystals. IN: Trudy Instituta fiziki i astronomii AN EstSSR, v. 39, 1972, 112-122. (LZhS, 52/72, no. 174215)

ii. Beam-Plasma Interaction

Granatkin, B. V., A. I. Isakov, and A. A. Tikhomirov. Scintillation counter for fast neutrons generated in a laser plasma. KSpF, no. 6, 1972, 62-68.

Kaliski, S. Some averaged properties of wave solutions for a hypersonic thermal wave. Bulletin de l'Academie Polonaise des Sciences, Serie des sciences techniques, no. 9, 1972, 297(641)-304(648).

Rayzer, Yu. P. Discharge propagation and maintenance of plasma density using electromagnetic fields. UFN, v. 108, no. 3, 1972, 429-463.

2. Effects of Strong Explosions

A. Abstracts

Molodtsov, V. K., and A. N. Tolstykh.
Calculation of hypersonic viscous flow around blunt bodies. IN: Trudy Sektsii po chislovym metodam v gazovoy, dinamike 2-go Mezhdunarodnogo kollokviuma po gazodinamike vzryva i reagiruyushchikh sistem, v. 1, 1969. Moskva, 1971, 37-54. (RZhRaketostroyeniye, 4/72, no. 4.41.153) (Translation)

In studying the aerodynamic characteristics of blunt bodies in a stream of low-density gas, when the forces of viscosity become significant, numerical integration of the Navier-Stokes equations becomes necessary. Results are presented from a study of supersonic viscous gas flow around the spherical nose portion of blunt bodies.

Bezmenov, V. Ya., and P. I. Gorenbukh.
Application of an unstable analogy to the study of the effects of an explosion wave on a barrier in a hypersonic tube. IN: Uchenyye zapiski TsAGI, v. 2, no. 6, 1971, 48-54. (RZhRaketostroyeniye, 4/72, no. 4.41.157) (Translation)

A method is described for applying the explosive analogy of hypersonic gas flow around blunt bodies in an experimental investigation of the effects of a strong explosion shockwave on a flat barrier. The effects are modelled based on the behavior of a shockwave departing from the nose of a flat blunt body onto a flat plate. The results are presented of pressure distribution measurements along the plate beyond an incident shockwave, generated in a helium hypersonic wind tunnel. The plate is set both at a zero angle of attack (nonmoving barrier) and at an angle of attack corresponding to the barrier motion $V_w = 0.25$. The experimental results are compared with calculated data.

Martynyuk, M. M., O. G. Panteleychuk, and V. I. Tsapkov. Melting of metallic wires by powerful current pulses. ZhPMTF, no. 4, 1972, 108-112.

Melting processes were investigated of Cu, Au, Cd, Zn, Pb, Pt, and Ni wire specimens subjected to a pulsed current of 100-450 μsec duration. Current and voltage oscillograms were obtained for all specimens and melting intervals (t_1, t_2, t_3) were fixed, as indicated in Fig. 1 for a Zn specimen. Relative resistance R/R_o (R_o - initial specimen resistance at 25° C) and enthalpy H (relative to 25° C) of solid and liquid phase close to melting temperature were then calculated by mathematical treatment of the obtained oscillograms on a Minsk-22 computer. Table 1 shows specimen parameters (r_o - radius, l - length at 25° C) and parameters of pulsed heating

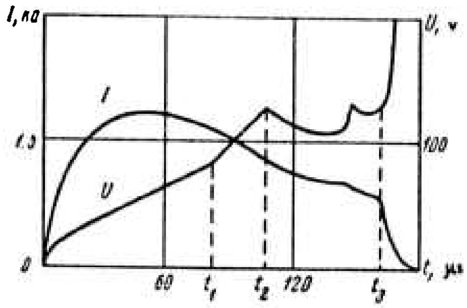

Fig. 1. Current and voltage oscillogram for Zn specimen.
t_1 - melting begins;
t_2 - melting ends;
t_3 - destruction begins.

process at moments t_1 and t_2 (Fig. 1); and calculated results are given in Table 2. Results for all metals except lead agree well with those of cited works by other authors. It was shown that Pt, Ni, Au, and Cu wire specimens started melting from the surface, after which the melting front moved radially toward the axis at an average velocity of a few meters per second. For the remaining metals, the interphase boundary moved in axial as well as radial directions. A discussion is given on the superheating of solid metals required for maintaining a high-speed movement of the interphase boundary. In the case of solid Pb, fusion was found to be possible at approximately 40° K above the melting temperature.

Table 1

Metal	r_0, mm	l, mm	t_1, µs	t_2, µs	$\frac{r_0}{t_2-t_1}$, m/sec	I, ka	P, Mw/g
Cu	0.155	54	108	165	2.72	2.7	240
Au	0.245	50	198	240	5.75	3.4	260
Cd	0.255	54	70	90	12.8	2.65	350
Zn	0.25	54	95	125	8.33	2.75	265
Pb	0.597	84	354	446	6.5	2.50	46
Pt	0.245	60	320	395	3.27	1.55	280
Ni	0.25	60	350	420	3.57	1.75	240

Table 2

Metal	Purity	ρ_0, µohm cm	R_1/R_0	R_2/R_0	$\gamma = R_1/R_2$	H_1, kj/g	H_2, kj/g	$H_2 - H_1$, kj/g
Cu	99.95	1.73	5.6	11.5	0.487	30	43.7	13.7
Au	99.95	2.29	5.4	12.0	0.450	29.0	41.8	12.8
Cd	99.95	7.84	2.4	4.25	0.565	8.7	15	6.3
Zn	99.975	6.10	2.8	5.75	0.487	11.1	18.5	7.4
Pb	99.9995	21.22	2.4	4.38	0.548	9.6	14.5	4.9
Pt	99.93	10.89	5.7	8.5	0.670	55	77	22
Ni	99.93	7.50	8.0	11.2	0.714	50	67	17

R_1/R_0, H_1 - refer to solid phase at time t_1

R_2/R_0, H_2 - refer to liquid phase at time t_2

Nayda, A. A., and V. K. Ovchinnikov. <u>Explosive loading effect on fiberglass-reinforced cylindrical shells.</u> PM, no. 9, 1972, 20-25.

The explosive load carrying capacity was calculated and tested of cylindrical shells made of a glass fiber fabric impregnated with type FFE-70 binder and wound on a metallic mandrel. An acetylene-oxygen mixture in a thin polyethylene envelope surrounding a shell was detonated. The shell and the envelope were clamped at the ends so that shell axial stresses were eliminated. Shell radial deformation was measured and recorded by oscillograph at 20-27 atm. pulse pressures for $(50\text{-}260)\times10^{-6}$ sec loading periods. Basically, only axisymmetric vibrations were recorded from L/R = 4 and R/h = 46 shells, where L, R, and h are length, radius, and thickness. Tests of shells with the same L/R but an R/h of 92, at increasing pulse amplitude to fracture revealed (Table 1) that the cracking load $K_{\Pi} = q_a/q_*$ increases when the pulse duration t_i is decreased (q_* is the critical static pressure). Fractures, with many cracks along the generatrix, normally occurred

Table 1

$t_и$, μsec	K_{Π}	Remarks	$t_и$, μsec	K_{Π}	Remarks
265	13,8		220	21,9	Fracture
265	23,6	Fracture	170	27,0	»
265	16,1		170	21,9	
265	18,0		170	23,6	
265	20,0	»	170	25,2	
220	20,0		170	27,0	»

when axisymmetric vibrations were converted into flexural ones. Flexure without fracture was observed in some tests. The problem of dynamic shell behavior was accordingly expressed by two nonlinear differential equations in terms of flexure W and the stress function Φ. A set of three differential equations was also derived with allowance for W, Φ, the time constant of the subcritical stress state development, and radial displacement periodicity. These equations were used to calculate the load carrying capacity of shells with $R/h = 92$, $h = 1$ mm, 1.44×10^{10} and 2.10×10^{10} n/m^2 longitudinal and radial Young moduli, and 0.35×10^{10} n/m^2 shear modulus. Calculated K_Π versus t_i/T_{ax} data agreed satisfactorily with the experimental critical K_Π data in Table 1.

Ponomarev, P. V. Determining fatigue failure limits for explosions and shocks. IVUZ Gorn, no. 8, 1972, 64-67.

Formulas for calculating the dimension x_o of the fatigue region in rocks, the demolition work factor W of a blast wave, and the number N of blast cycles necessary for rock demolition, are derived from equations of energy and the Poynting vector balance. These two equations describe the total energy wave propagation in a rock. In the first approximation, the dissipation function Ψ, numerically equal to the energy absorbed in the unit volume, is given by

$$\psi = \alpha I + \gamma (I - I_r)^n. \tag{1}$$

where $I = \epsilon c$ is the Poynting vector, ϵ is the energy density, and $I_r = \sigma_r / \rho_r^2$ is the mininum wave intensity for initiating demolition work W (σ_r is the rock fatigue limit). The equation of energy is reduced to

$$I' + \alpha I + \gamma (I - I_r)^n = 0. \tag{2}$$

Equation (2) is solved for I at n = 1 and 2. The formulas for x_o, the maximum distance at which demolition occurs, are derived from the solutions of (2). The formula for W per unit time

$$w_1 = \gamma (I - I_r)^n. \tag{3}$$

is derived from (1). A blast wave in the fatigue demolition region is approximated by a single sinusoid. In this approximation, the formulas for $W = W_1 T$ at n = 1 and 2 are derived from (3) and the respective solutions of (2). The number N is determined from the equality $W_{sp} = NW$, which gives

$$N = \frac{w_{sp}}{\gamma_0 (I - I_r)^n} = \frac{w_{sp} (\rho c)^n}{\gamma_0 (\sigma^2 - \sigma_r^2)^n}. \tag{4}$$

where $\gamma_o = \gamma T$ is the damping factor and T is the wave period. The Fig. 1 plots of N versus X, the distance from the wave source, show that N increases with an increase in X. At some distance x_o, $N = \infty$, and at $X > X_o$ fatigue demolition does not occur.

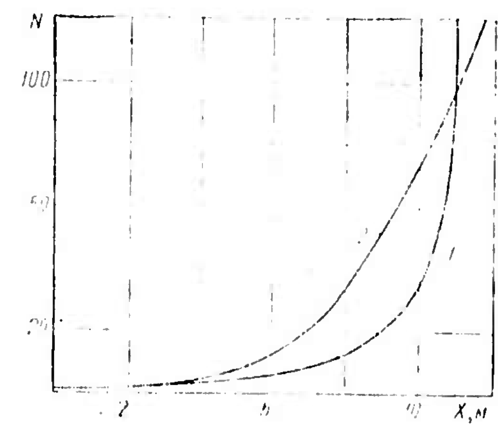

Fig. 1. Number of wave cycles versus the distance from free surface: $\gamma_o = 10^{-4}$, $T = 10^{-3}$ sec, 1 - n = 1, 2 - n = 2.

Zhdan, P. A., B. V. Mitrofanov, V. P. Ivanov, V. N. Kolomiychuk, and S. S. Batsanov. Manufacture of optical ceramics by explosive molding of inorganic compound powders. NM, no. 10, 1972, 1879-1880.

The effect of explosive molding on the transmissivity and strength of polycrystalline LiF and NaF samples was studied experimentally, to explore the feasibility of manufacturing optically transparent components by this method. Powdered samples of varying particle size and purity were compacted in metal containers and subjected to dynamic loading by plane or cylindrical detonation waves. Detonation was initiated by a low-density ($1.1\ g/cm^3$) RDX charge with a 35-100 m diam. or 50-500 g weight, resulting in an unloading wave pressure drop rate within 4-11 μsec. The initial packing density was ~85% of the container. At a detonation velocity of 6.2 km/sec, pressure and temperature in the leading wave were calculated to be ~200 kbar and 800° C for LiF and ~250 kbar and 1000° C for NaF. Compact cylindrical samples of densities 99.4-99.6% and 99.8-99.9% of the theoretical values were obtained by single and double loadings, respectively. Of the twice-loaded samples, only the spectral grade LiF sample displayed good transparency (Fig. 1).

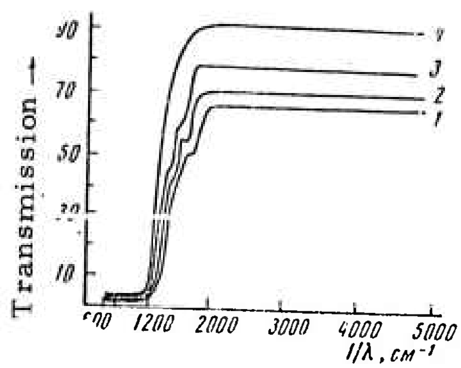

Fig. 1. IR transmission curves of 1 mm thick, spectral grade LiF samples after explosive processing, 1 - 30-50 μ, 2 - 10-15 μ, and 3 - 30-50 μ, after two consecutive explosive moldings; 4 - original LiF single crystal.

The singly-molded LiF samples, with a 3-5 μ particle size and ~1.2% impurities, exhibited the highest relative microhardness H and density, presumably owing to impurities implantation into the crystal lattice. The transmissivity and H of the explosion-molded samples decreased after annealing at 100-600° C. The final H value for LiF samples annealed at 600° C was about the same as the H value for samples statically compacted at room temperature and subsequently annealed at 600° C. It was concluded that relatively strong optical ceramics can be produced by explosive molding at substantial savings in comparison with hot molding of ceramics.

Anisimov, S. I., and O. M. Spiner. Motion of a near-ideal gas from a powerful point explosion. PMiM, no. 5, 1972, 935-938.

Two examples are given to illustrate the strong dependence on the selection of the equation of state of a self-similar solution to a powerful point explosion problem. The first example is a calculation of the adiabatic motion of a near-perfect gas with an initial density ρ_0 such that $b\rho_0 \leq 1$, where $b = \lim B(T)$ at a T well above the critical gas temperature. The gas heat capacity is assumed to be constant. The virial expansion of the equation of state can be limited to

$$p = \rho RT(1 + b\rho) \tag{1}$$

The gas motion can therefore be described by the energy and adiabatic integrals and a first order differential equation in self-similar variables $V(\lambda) = vt/r$, $g(\lambda) = \rho/\rho_0$, and $\lambda = r(\rho_0/Et^2)^{1/5}$, where E is the explosion energy. Within the region $r \sim r_2\sqrt{b\rho_0}$, where r_2 is the shock wavefront radius, the $V(g_*)$ profile of the dimensionless velocity $V(\lambda)$ (where $g_* = \alpha g$) is shown to be nonmonotonic in contrast to the monotonic V(g) profile for a perfect gas. Near the symmetry center $\lambda = 0$,

$$V(\lambda) \sim {}^{2}/_{5}\, \gamma^{-1} - a\lambda^{3(\gamma-1)} \tag{2}$$

a nonmonotonic function exists, while in a perfect gas

$$V(\lambda) \sim 2/5\, \gamma^{-1} + C\lambda^{(2\gamma+1)/(\gamma-1)} \tag{3}$$,

where $a > 0$, $c > 0$, and γ is the ratio of heat capacities at $\rho = 0$. As the imperfection parameter $\alpha = b\rho_0 (\gamma - 1)$ approaches zero, (2) does not evolve into (3).

In the second example, the nonperfect heat-conducting gas state is described by the equation

$$p = \rho R T [1 + \rho B(T) + \rho^2 C(T) + \ldots] \tag{4}$$

The self-similar model of a strong explosion in such a gas is a set of ordinary differential equations. On the basis of these equations, dimensionless velocity, density, and temperature values are formulated for the region near the symmetry center. These formulas show that as $\alpha \to 0$, the asymptotic expressions for a near-perfect gas change to the corresponding expressions for a perfect gas. A smooth transition from an imperfect heat-conducting gas to a perfect gas is accordingly made, in contrast to adiabatic motion.

B. Recent Selections

i. Shock Wave Effects

Adadurov, G. A., V. V. Gustov, A. M. Kaplan, M. Yu. Kosygin, and P. A. Yampol'skiy. Shock wave initiated polymerization of acrylamide. FGiV, no. 4, 1972, 566-570.

Bakulin, A. I., L. Ye. Belogolov, I. I. Boyko, B. I. Krupenya, Yu. I. Mashnikov, and V. K. Shabunin. Device for rupturing a gas dynamic shock tube diaphragm. Otkr izobr, no. 34, 1972, no. 358634.

Bespalova, Ye. I., M. I. Vorotnikova, and V. O. Kononenko. Shock wave diffraction from an absolutely rigid stationary cylinder in water. PM, no. 11, 1972, 3-8.

Bordzilovskiy, S. A., S. M. Karakhanov, and V. V. Polyudov. Study of e.m.f. in metal vapors under shock compression. FGiV, no. 4, 1972, 586-590.

Golubykh, S. M., and B. A. Gordiyenko. Axial shock characteristics of bimetallic cylindrical shells. IN: Sbornik. 4-ya Vsesoyuznaya konferentsiya po problemam ustoychivosti v stroitel'noy mekhanike, Moskva, 1972, 154-155. (RZhMekh, 12/72, no. 12V339)

Khanukayev, A. N., V. Ya. Bril', and V. P. Belyatskiy. Calculating shock wave parameters in a near-blast zone. IN: Sbornik nauchnykh trudov. Krasnodarskiy politekhnicheskiy institut, no. 14, 1971, 68-83. (RZhMekh, 12/72, no. 12B199)

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Sil'vestrov, V. V., V. M. Titov, and V. P. Urushkin. Study of gas flow from dynamic loading of liquid nitrogen and liquid hydrogen. IN: Sbornik. Dinamika sploshnoy sredy, Novosibirsk, no. 10, 1972, 233-238. (RZhMekh, 12/72, no. 12B202)

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Voytenko, A. Ye., M. A. Lyubimova, and Ye. P. Matochkin. An explosive shock tube. TVT, no. 6, 1972, 1280-1284.

Yel'kin, Yu. G. Nonstationary one-dimensional flow of an inviscid radiating gas. IN: Uchenyye zapiski TsAGI, v. 3, no. 2, 28-38. (RZhMekh, 12/72, no. 12B171)

ii. Hypersonic Flow

Blokhin, V. I., V. A. Konotop, and A. S. Filatov. High temperature supersonic wind tunnel with arc heating of the gas. Otkr izobr, no. 35, 1972, no. 359565.

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iii. Soil Mechanics

Adushkin, V. V., and L. M. Pernik. Characteristics of subsidence crater formation. FGiV, no. 4, 1972, 541-552.

Anoshina, A. P., Ye. I. Orekhov, and A. A. Dudin. Feasibility of using seismic methods for studying underground cavities. IN: Sbornik trudov Vsesoyuznogo nauchno-issledovatel'nogo gorno-metallurgicheskogo instituta tsvetnykh metallov, no. 24, 1972, 164-170. (LZhS, 52/72, no. 174640)

Antonyuk, A. Ye. Effect of foundation design on seismic resistance of structures. IN: Sbornik. Proyektirovaniye i stroitel'stvo zdaniy v seysmicheskikh rayonakh UkrSSR i MoldSSR, Kishinev, Izd-vo Timpul, 1972, 163-175. (RZhMekh, 12/72, no. 12B841)

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3. Geosciences

A. Abstracts

Lopatina, N. P., and V. Z. Ryaboy. Velocity and density discontinuities in the upper mantle in USSR territory. IN: Akademiya nauk SSSR. Doklady, v. 207, no. 2, 1972, 337-340.

Data on discontinuities in the mean velocity in the upper mantle ($\overline{V}_{M+150}$, 150 - 200 km below the Moho discontinuity) are reviewed. The Bouguer anomaly $\Delta g'$ due to the 150 - 200-km-thick layer of the upper mantle was calculated. The distribution of $\Delta g'$ reaching ±200 mgal, is shown in Fig. 1. An empirical formula for the relationship between $\overline{V}_{M+150}$

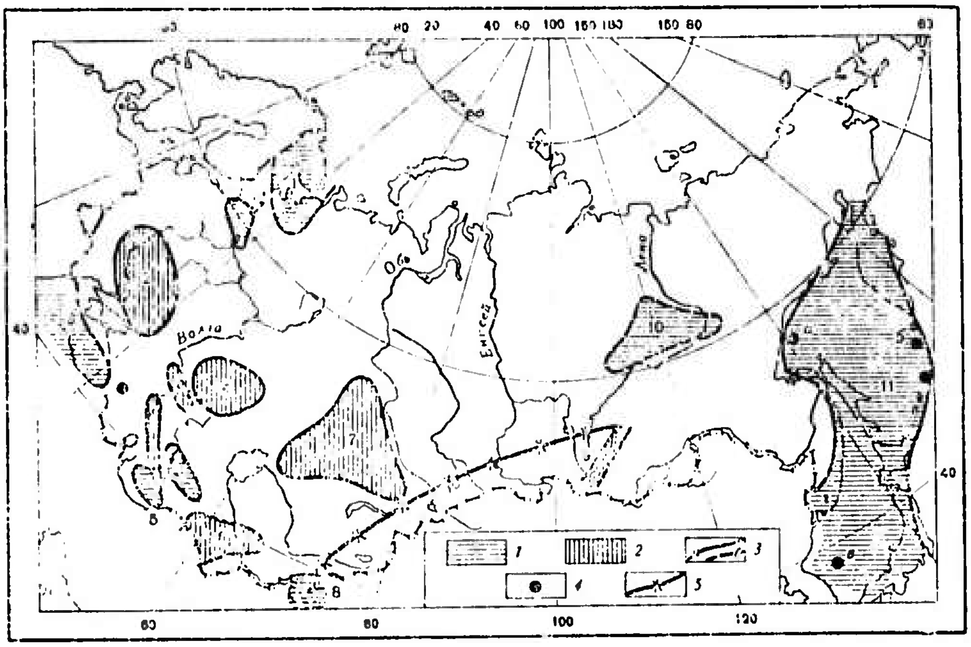

Fig. 1. Zones of Anomalous Physical Parameters of the Upper Mantle in the Territory of the USSR.

1 - negative anomalies of $\Delta g'$, $\overline{V}_{M+150}$ and $\overline{\sigma}_{M+150}$;
2 - positive anomalies;
3 - boundaries of anomalous zones;
4 - regions where velocity distribution for the upper mantle was determined from seismological data;
5 - seismological profile Pamir-Baykal, along which the upper mantle structure was studied.

and $\Delta g'$ was derived from seismological data obtained along a 3500-km-long profile crossing Pamir, Tien-Shan, Altay, Sayany and the Baykal rift zone, as well as in the Japan Islands, Kurile-Kamchatka zone, Far East and Caucasus. This formula was used for the calculation of $\overline{V}_{M+150}$ for regions where seismological data were lacking. The density of the 150-200 km layer was determined approximately from $\overline{V}_{M+150}$.

	$\Delta g'$ mgal	$\overline{V}_r^M$ km/sec	$\overline{V}_{M+150}$ km/sec	$\overline{\sigma}_{M+150}$ gr/cm^3
1. Baltic shield and its slopes	-90	8.1-8.3	8.00*	3.3
2. Ukrainian and Voronezh crystalline massifs	+70	8.2-8.4	8.25*	3.4
3. Black Sea	-150	8.0-8.2	7.95*	3.3
4. Peri-Caspian syneclise	+100	8.0-8.5	8.30*	3.4
5. South Caspian depression	-100	8.0-8.2	8.05*	3.3
6. Southeastern Turkmeniya	+150	8.2-8.3	8.35*	3.4
7. Central Kazakhstan massif	+80	8.2-8.5	8.25*	3.4
8. Pamir	-100	-	8.00	3.3
9. Baykal rift region	-50	7.7-7.8	7.95	3.3
10. Vilyuyskaya syneclise	-100	-	8.05*	3.3
11. Transition zone from the Asian continent to the Pacific Ocean				
a). Kurile-Kamchatka zone	-100	7.9-8.0	7.85	3.25
b). Western part of the Sea of Okhotsk	-150	8.1	8.00	3.3
c). Japan island arc and the eastern part of the Japan Sea	-200	7.7-8.0	7.7	3.2
d). Western part of the Japan Sea and Primor'ye	-200	8.2-8.3	7.7	3.2

The relationship between zones of anomalous $\Delta g'$ and $\overline{V}_{M+150}$ and the crustal structure is complex and ambiguous.

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*) Assumed values based on the correlation between $\overline{V}_{M+150}$ and $\Delta g'$. Numbers of structures in table correspond to those given in Fig. 1.

Rezanov, I. A. Basaltic layer of the earth's crust. Sovetskaya geologiya, no. 9, 1972, 12-25.

Geological and seismic data on the "basaltic" layer accumulated to date are reviewed. Conclusions are drawn concerning its composition, geological age, and origin. The "basaltic" layer in ancient platforms and geosynclinal folded systems of different age is considered.

The "basaltic" layer in the shields of ancient platforms has maximum thickness and poor differentiation. In the Baltic shield, along the Kem'-Ukhta DSS profile, only two distinct interfaces are found: the Conrad discontinuity at depths of 8-15 km with V_r = 6.6 km/sec and the Moho discontinuity of depths of 34-38 km. Along the DSS profile intersecting the Baltic shield and the Barents Sea, two distinct interfaces are found, one at 3-4 to 7-8 km with V_r = 6.3-6.8 km/sec, and the Moho discontinuity at a depth of 70 km (see Fig. 1). Interfaces within the "basaltic" layer are traced discretely and somewhat less reliably. An interface at 7-15 km is considered by the author as being the bottom of the primary sedimentary crust underlain by a layer of the upper mantle, which is "debasified" in the process of isostatic readjustment. The "basaltic" layer in the shields of ancient platform is older than metamorphosed sedimentary rock corresponding to the initial stage of the earth's crustal development. The "basaltic" layer in the geosynclinal folded systems has different origin. In the Caucasian - Turkmenian part of the Mediterranean belt of folding, there exist at least two types of the "basaltic" layer. Thus, beneath the greater Caucasus meganticlinorium, the "basaltic" layer has prevailing submeridional structural trends (see Fig. 2c), which is characteristic of the basement of the adjacent ancient platforms. The "basaltic" layer is formed from metamorphosed Archean-Lower Proterozoic formations. However, in the southern Caucasian trough and southern Caspian and cis-Balkhan depressions

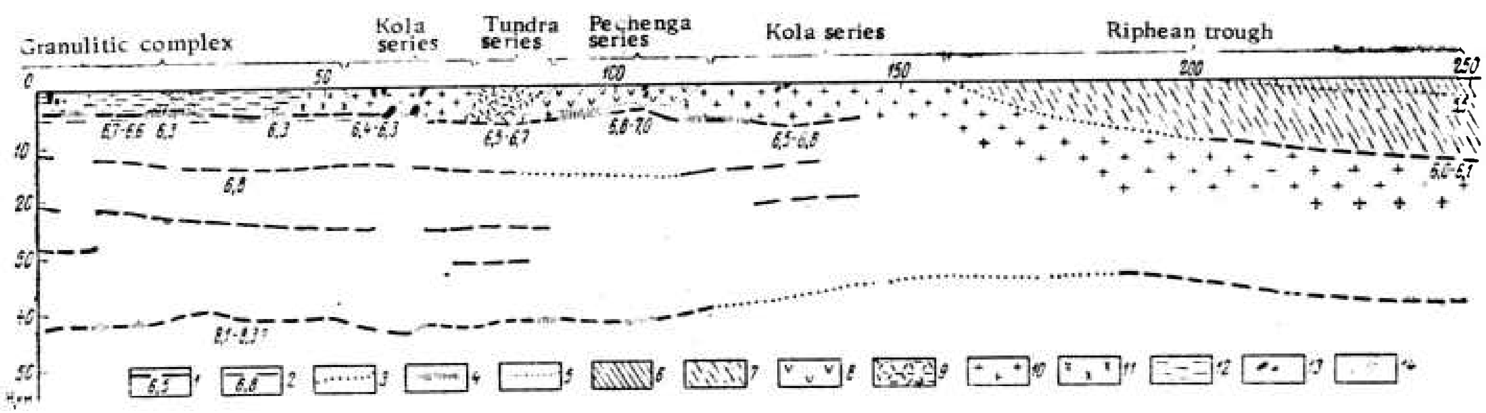

Fig. 1. DSS profile Barents Sea - Lovno (after I. V. Litvenenko)

1 - distinct seismic interfaces and their refractor velocities in km/sec; 2 - other seismic interfaces; 3 - assumed seismic interfaces; 4 - sectors corresponding to the gaps in seismic wave correlation; 5 - geological boundaries; 6-11 - formations of varying petrological composition.

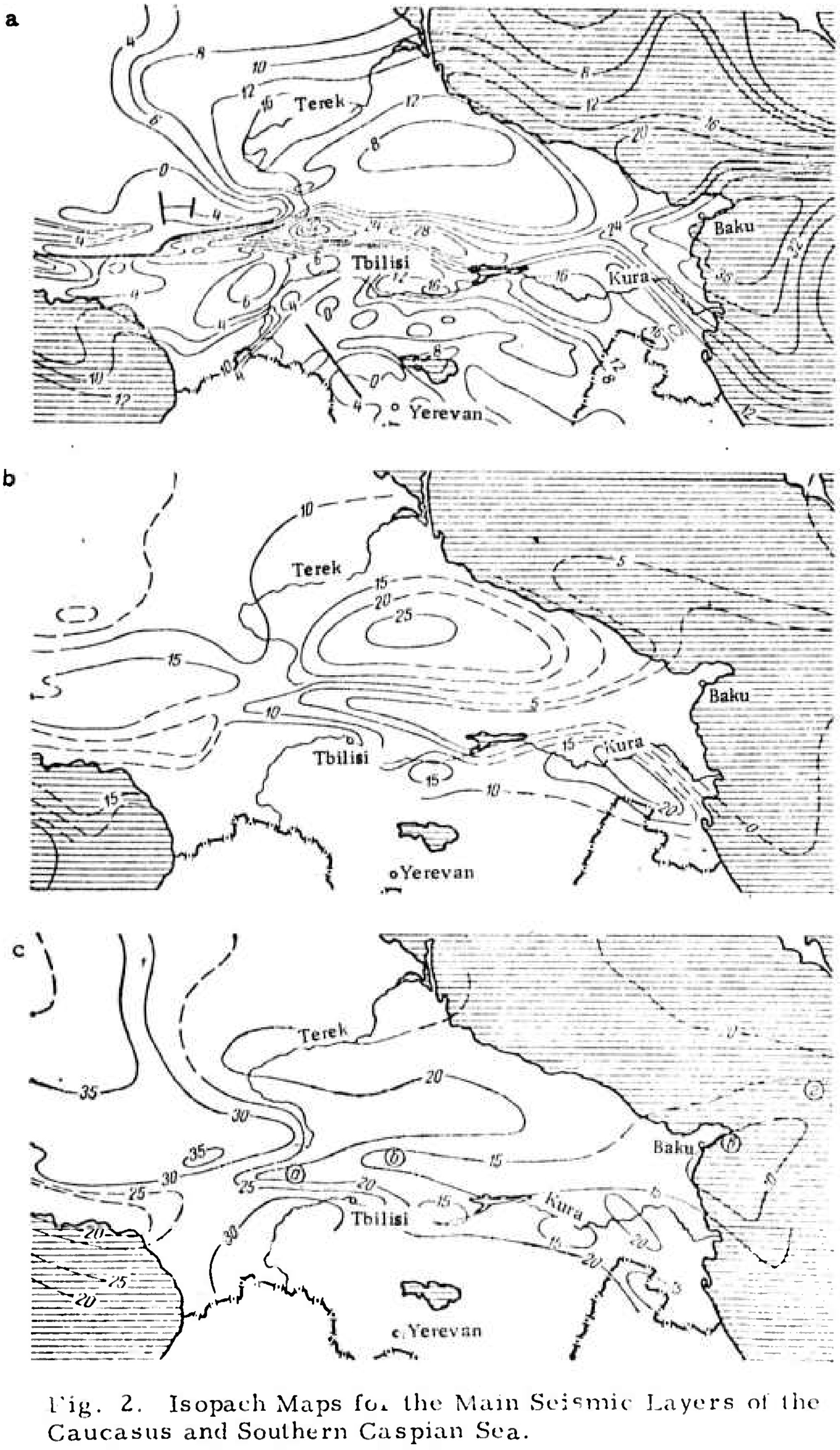

Fig. 2. Isopach Maps for the Main Seismic Layers of the Caucasus and Southern Caspian Sea.

a - Alpine and Hercynian folded complexes; b - "granitic" layer; c - "basaltic" layer.

(see Fig. 3), the Moho discontinuity and the top of the "basaltic" layer

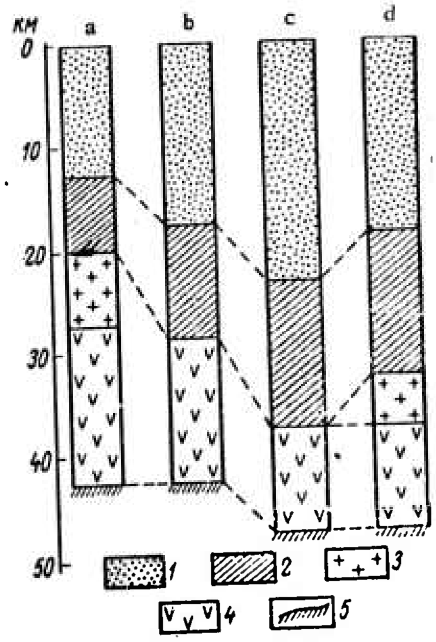

Fig. 3. Crustal Columns for the Axial Part of the Southern Caucasian Trough and Southern Caspian Depression.

1 - Alpine sedimentary complex; 2 - Hercynian complex; 3 - Pre-middle-Paleozoic portion of the "grantic" layer; 4 - "basaltic" layer; 5 - Moho discontinuity and upper mantle; a, b, c, d - locations of the crustal columns as in Fig. 2c.

migrated upwards, which implies that they are superposed in the process of the sinking of crustal material into the mantle. Thus, the "basaltic" layer (the secondary one) represents basified Upper-Proterozoic and partly Paleozoic setiments. The secondary "basaltic" layer is observed in the platform depressions as well as in the inland seas. In the peri-Caspian syneclise, the "basaltic" layer, with small (7-13 km) and steady thickness, is overlain by a thick sedimentary complex (see Fig. 4). High seismic

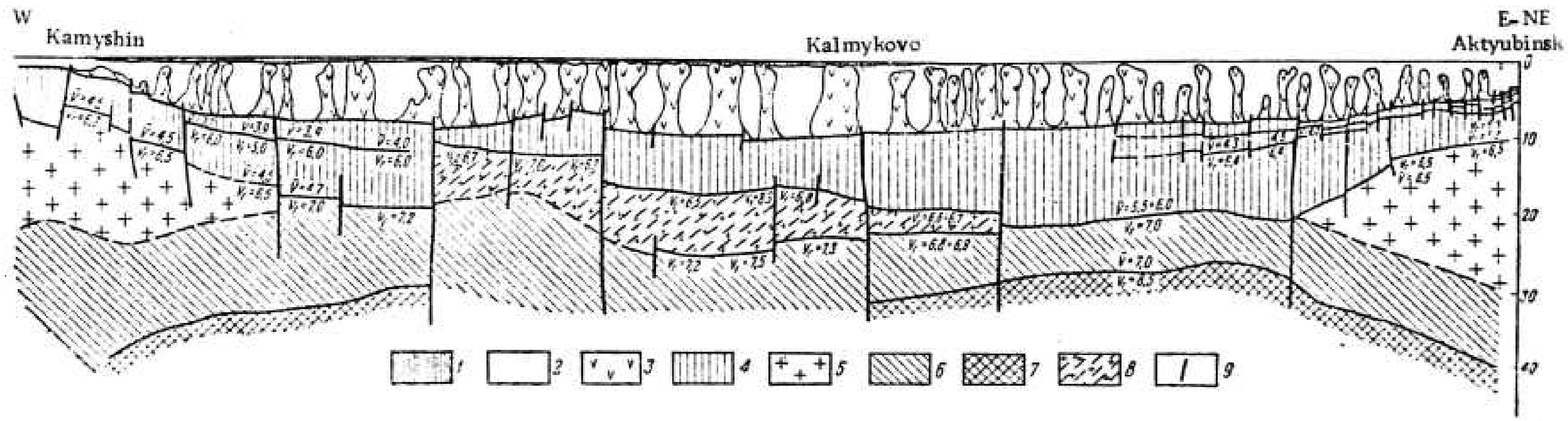

Fig. 4. Seismogeological Section of the Peri-Caspian Syneclise

1 - Upper-Pliocene sediments; 2 - Paleogene, Mesozoic and Upper Permian sediments; 3 - salt stocks and banks; 4 - Lower and middle Paleozoic and Riphean sedimentary layer; 5 - "granitic" layer (Pre-Riphean basement of the East European platform); 6 - "basaltic" layer; 7 - upper mantle; 8 - basified sedimentary and, possibly, "granitic" layers; 9 - deep faults.

velocity in the lower part of the sedimentary complex indicates the onset of the initial stage of basification. The same type of sedimentary - basaltic crust is observed in the Black and Mediterranean Seas. Furthermore, both in the geosynclinal folded systems and platforms, the "basaltic" layer may have been formed from solid ultrabasic material squeezed out of the mantle, (which is subsequently serpentinized), or from thin basic intrusions inter-layered with crustal layers (the Ukrainian shield).

The conclusion is made that the "basaltic" layer of the continental crust is formed from rocks of different hetrological composition, age, and origin. The rocks constituting the "basaltic" layer range from intermediate to ultrabasic. Their age varies from older than Katarchean to Upper Proterozoic, and Palozoic. The "basaltic" layer is formed from a) "debasified upper mantle substance in the regions of steady uplifting; b) from basified "granitic" layer or sediments in regions of steady subsidence; c) from Ardiaic and Lower Proterozoic sedimentary and volcanic formations transformed in the process of regional metamsoplinsn; d) from interstratified acidic crustal substance and basic intrusions; and e) from interstratified ultrabasic mantle substance injected into the crust.

Shevchenko, V. I., and I. A. Rezanov.
Deep geological structure of the western part of the Caucasus, Crimea and the adjacent Black Sea basin. IN: Akademiya nauk SSSR. Izvestiya. Seriya geologicheskaya, no. 10, 1972, 3-18.

A geological interpretation is given to deep seismic sounding (DSS) data on the deep crustal structure of the Black Sea and its folded surroundings. The interpretation, somewhat different from previous ones, is based on the latest concepts of the geosynclinal development of the Mediterranean belt of folding and concepts of the tectonics of adjacent Caucasus, Caspian and western Turkmeniya, derived from DSS results.

Similar to the adjacent regions, four major inter-crustal interfaces are found in the territory of the Black Sea and its folded surroundings (see Fig. 1). The first three of these correspond to the bottom of the Alpine,

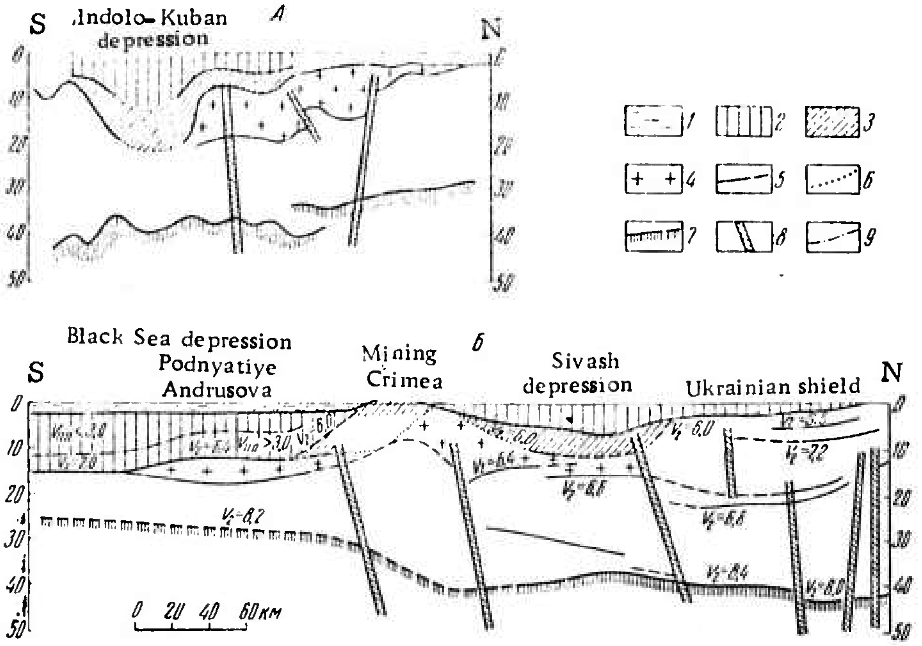

Fig. 1. Seismogeological Profiles Through the Western Cis-Caucasus Region (A) and the Ukrainian Shield - Crimea - Black Sea (B).

1 - water; 2 - Alpine folded complex; 3 - Hercynian folded complex; 4 - Baikalian (?) folded complex; 5 - reliable and less reliable seismic interfaces; 6 - interpolated seismic interfaces; 7 - bottom of the earth's crust; 8 - faults; 9 - boundary between layers with layer velocity < 3.0 km/sec and V > 3.0 km/sec.

Hercynian and Baikalian folded complexes, while the fourth is the Moho discontinuity. The Moho discontinuity relief is similar to that in the adjacent regions. Thus, the Moho discontinuity, which is inverse to the bottom of the Alpine and Hercynian complexes, subsides in the regions of uplifts (40-45 km in the eastern Black Sea rise), while it rises in the regions of depressions 20-25 km in the axial part of the Black Sea. Maps of depth isopleths for the bottom of the Alpine (Fig. 3) and Hercynian (Fig. 4) folded

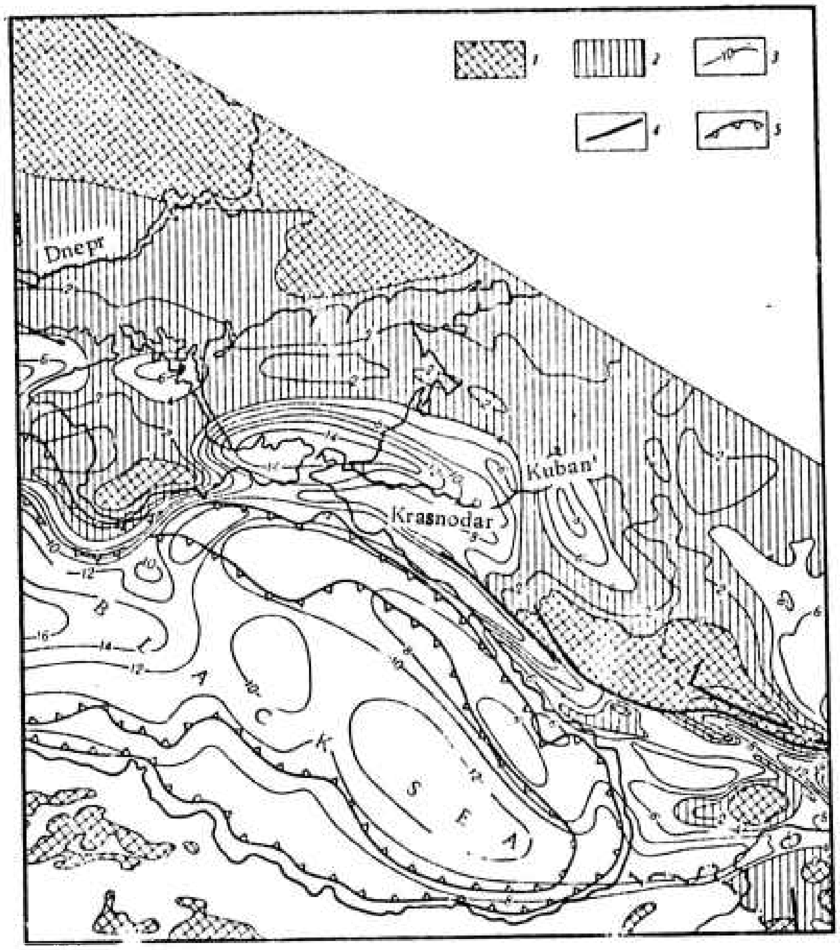

Fig. 3. Depth Isopleth Map for the Bottom of Alpine Folded Complex.

1 - depth exceeding 0 m;
2 - depth 0-4 km;
3 - depth isopleths;
4 - faults;
5 - upper and lower boundary of the continental slope.

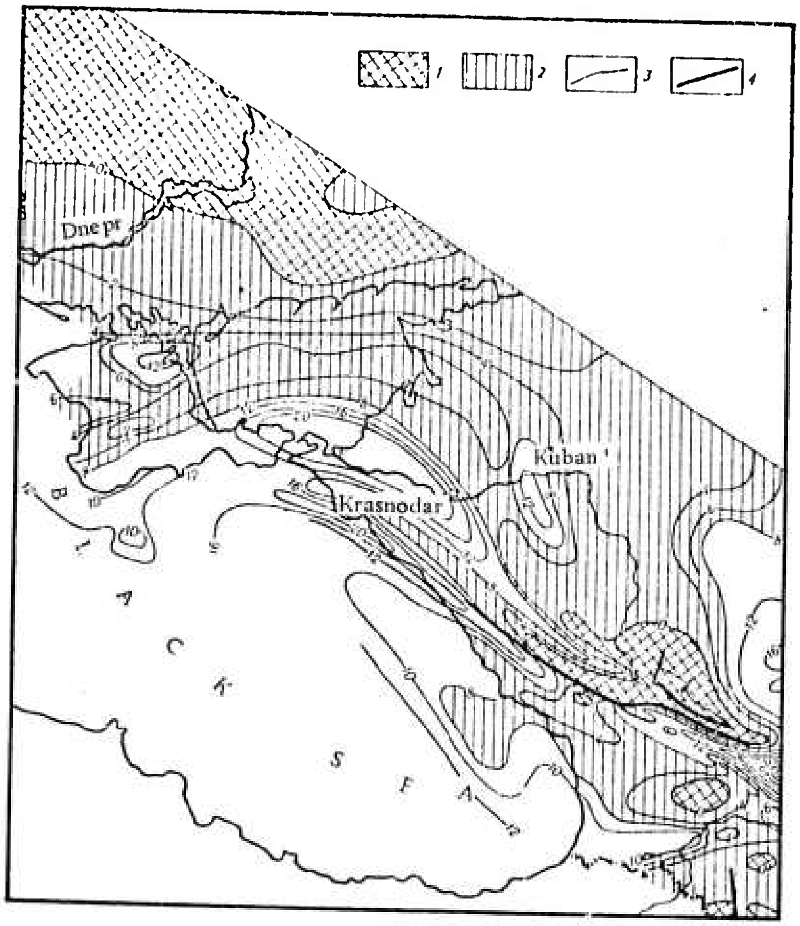

Fig. 4. Depth Isoline Map for the Bottom of Hercynian Folded Complex.

1 - depth exceeding 0 m;
2 - depth 0-8 km;
3 - depth isopleths;
4 - faults.

complexes, as well as isopach maps for the Hercynian (Fig. 2) and

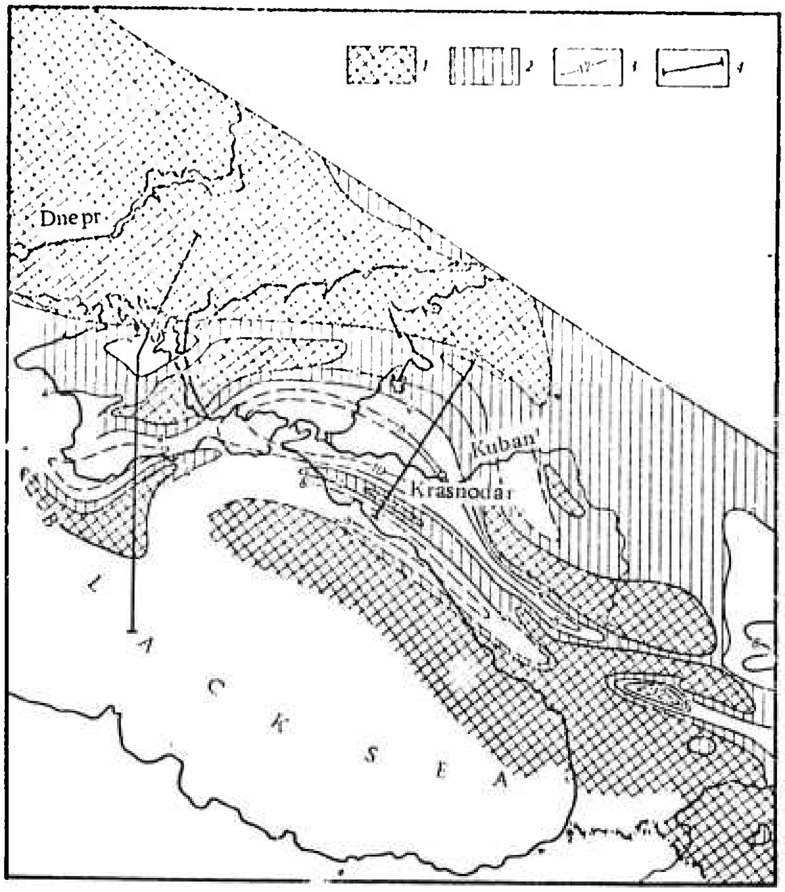

Fig. 2. Isopach Map for Hercynian Folded Complex.

1 - complex absent;
2 - 0-4 km thick;
3 - isopachs;
4 - seismic profiles

Baikalian (Fig. 5) folded complexes and the crust (Fig. 6), summarize all the available DSS data for the region under study.

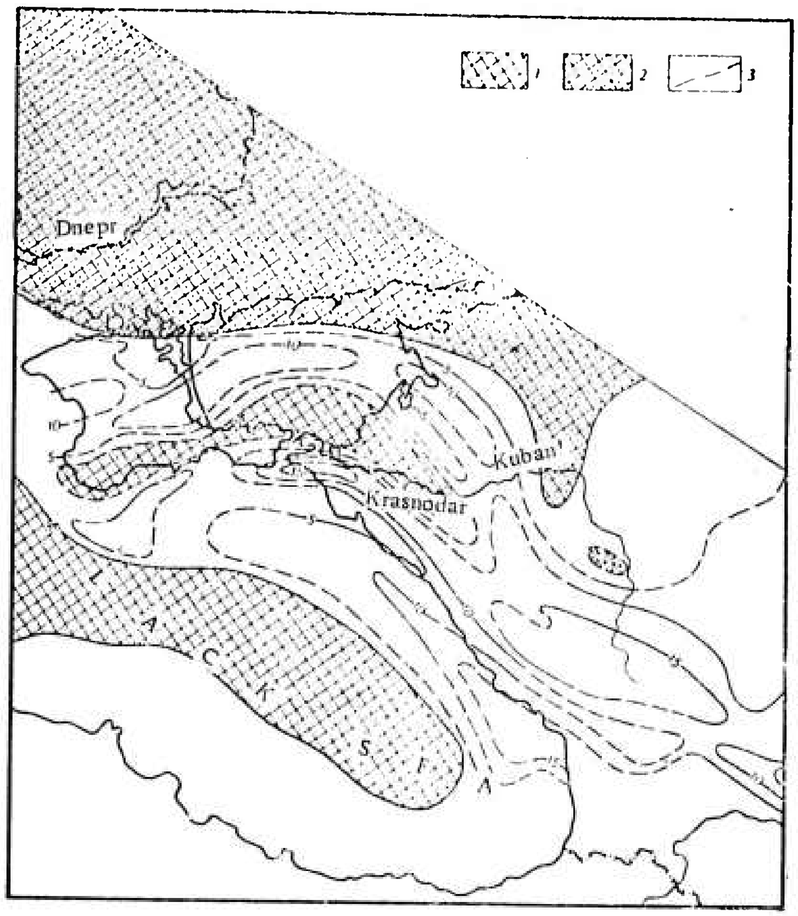

Fig. 5. Isopach Map for the Baikalian (?) Folded Complex.

1 - Baikalian (?) complex or "granitic" layer absent;
2 - Baikalian complex primarily absent (sic);

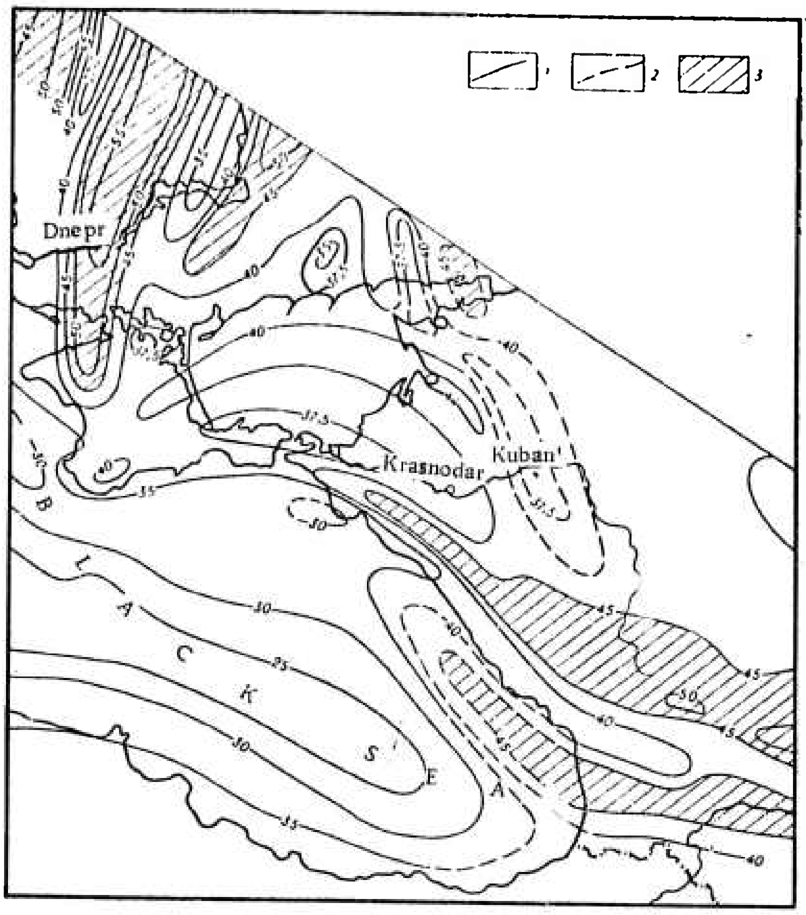

Fig. 6. Isopach Map for the Crust

1 - isopachs;
2 - the same, presumably;
3 - crustal thickness exceeds 45 km

The deep structure of depressions and uplifts are found to be essentially similar both in the Black Sea basin and on the continent. The depressions are characterized by thick Alpine and, in most cases, Hercynian folded complexes. The uplifts are characterized by reduced thickness of the complexes. Beneath the depressions on the continent, the

Baykal folded complex (Pre-Middle-Paleozoic portion of the "grantic" layer) is thin or sharply reduced, whereas beneath the Black Sea basin, the "granitic" layer thins out. Furthermore, the relationship between surface structures and the Moho discontinuity relief is found to be identical for both the continent and Black Sea basin.

It is concluded that the tectonic development of the Black Sea basin and its surroundings is identical to that of the Caucasian isthmus, i.e., connected with geosynclinal processes.

The Black Sea megadepression is superimposed, i.e., independent of the geosynclinal processes during the Hercynian and Alpine stages which resulted in the same differentation in the Black Sea basin and the Caucasian isthmus.

The thinning out of the "granitic" layer in the Black Sea basin is attributed to the normal geosynclinal process, and occurs as well beyond the "suboceanic" depression.

Bulin, N. K., N. A. Afanas'yeva, Ye. A. Pronyayeva, Ye. I. Erglis. Deep section of the southeastern part of the Siberian platform and its folded surroundings, based on seismological data. Sovetskaya geologiya, no. 10, 1972, 134-140.

The results of crustal and upper mantle studies along the Dzhalinda-Ulu profile (Fig. 1) are described, based on PS-converted waves from earthquakes. Earthquakes with $\Delta = 10\text{-}140^{\circ}$ (mainly originating in the

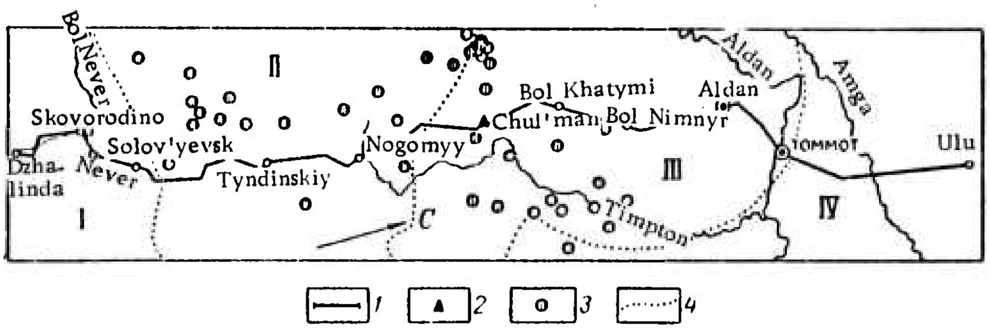

Fig. 1. Location of the Geological-Geophysical Profile.

1 - Profile line; 2 - seismographic recording station; 3 - epicenters of local earthquakes; 4 - boundaries of the folded systems; Folded systems: I - Mongolo - Okhotskaya; II - Olekno - Stanovaya; III - Iyengrskaya; IV - Timptono - Dzheltulinskaya.

the circum-Pacific seismic belt) were observed at 86 points by nine standard regional and two "Zemlya" seismograph systems. The velocity - depth distribution was inferred from data on local earthquakes and industrial explosions (for the crust) and intermediate earthquakes (for the 55-250 km range).

The crustal section is shown in Figure 2. Two sharp conversion surfaces within the crust are traced nearly continuously along the entire profile, i.e., G at depths of 8-12 km and M at depths of 36-43 km. Conversion surfaces G_1, B and B_1 are traced discretely. In the upper mantle, six conversion surfaces in the 57-230 km depth range are traced over relatively long intervals, the crust and upper mantle are divided into blocks by vertical and inclined abyssal zones. Zones penetrating to greater depths correlate well with geologically determined abyssal fault zones. The following consists of descriptions of the deep structure of the tectonic zones which are crossed by the profile.

Amga monoclise. The crustal thickness in this tectonic zone is 40-41 km, the crust is characterized by considerable differentiation and

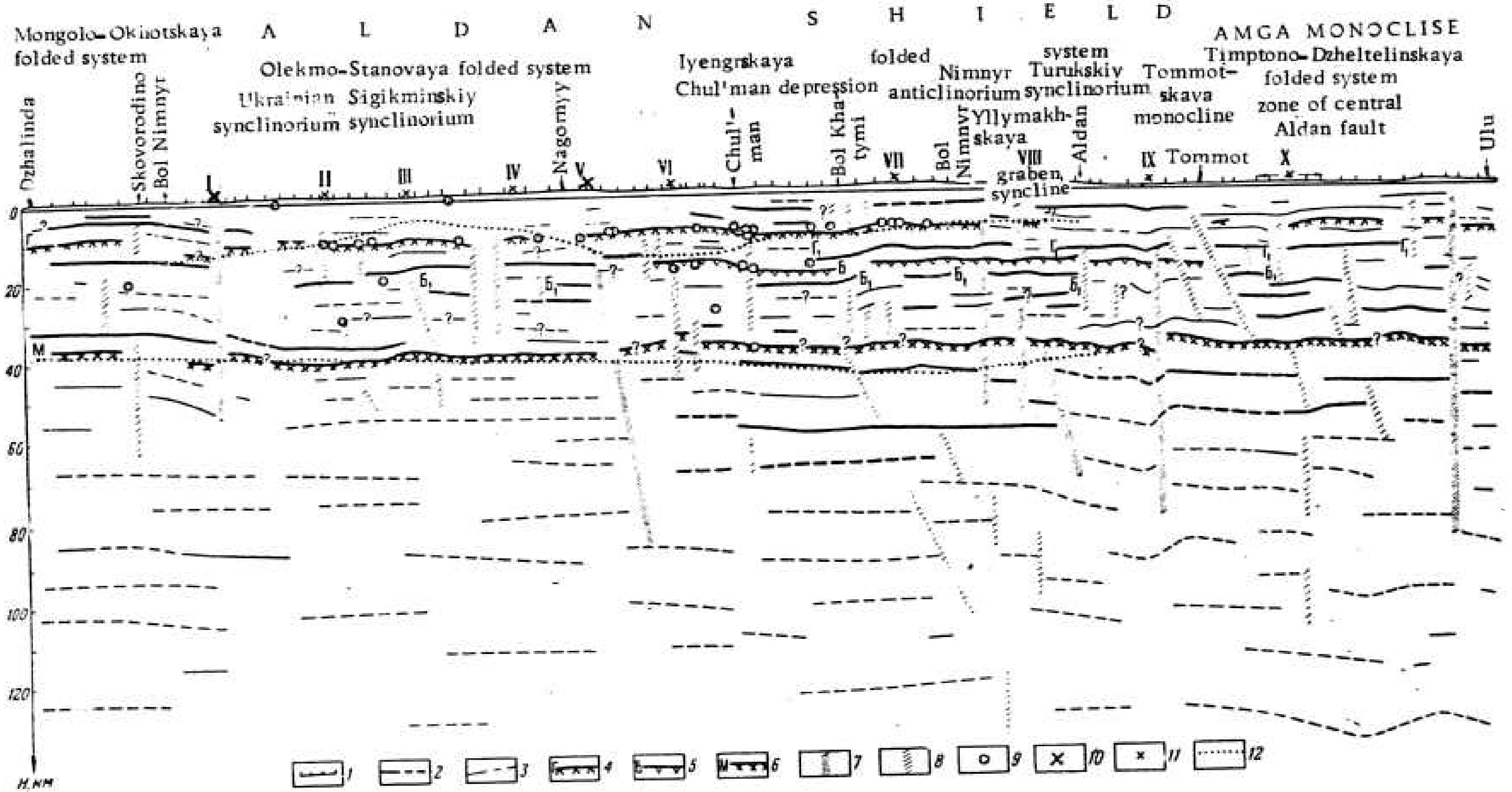

Fig. 2. Deep Section Along the Dzhalinda - Never - Aldan - Ulu Profile.

1 - observation points; 2 - distinct conversion surfaces; 3 - other conversion surfaces; 4 - G horizon within the "granitic" layer; 5 - Conrad discontinuity; 6 - Moho discontinuity; 7, 8 - near vertical and inclined abyssal zones: (7 - of the first order, 8 - of the second order); 9 - injections of earthquake epicenters within a 100 km-wide strip; 10, 11 - fracture zones (from geological data); 10 - boundary faults (I, V), 11 - faults; 12 - crustal interfaces (after Lishnevskiy and al., 1968).

an interface at 7-8 km which is more distinct than interface G. The central Aldan fault, which is geologically very clearly manifested, is not reliably identified, although an abyssal zone identified at the northern end of the zone is not confirmed by geological or other geophysical data.

Iyengrskaya folded system. The crust in this zone is 39-43 km thick, and the Moho discontinuity relief is more pronounced. The Conrad discontinuity (interface B) was continously traced within this zone, while the G interface was found only in its southern part. Abyssal zones are mainly confined to the junction of the Nimnyr anticlinorium and Turukskiy synclinorium and to the northern part of the Chul'man depression.

Olekmo-Stanovaya folded system. This zone is characterized by a crustal thickness of 37-41 km, continuously traced G and M interfaces, and discretely traced Conrad discontinuity. The Moho discontinuity relief is gentle. An interface more distinct than the Moho discontinuity is found 4 km above the Moho. Seven near-vertical zones identified correlate with abyssal fault zones.

Mongolo-Okhotskaya folded system. The minimum crustal thickness (36-40 km) along the profile is observed in this zone. The Moho discontinuity is identified less reliably than in other tectonic zones. A very distinct interface is found above the Moho discontinuity. All interfaces are dislocated by 2-3 km at the northern boundary of the zone. The abyssal zone extending to a depth of 55 km is correlated with the southern border of the Mongolo-Okhotskaya marginal fault. (I).

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4. Particle Beams

A. Abstracts

Aronov, B. I., and A. A. Rukhadze. Energy flow of e-m radiation during beam instability development in a magnetized plasma. ZhTF, no. 8, 1972, 1606-1609.

This paper considers the theoretical problem of electromagnetic wave excitation by relativistic electron beams in a magnetoactive plasma confined in a metallic waveguide. Expressions are obtained for wave dispersion and the dielectric tensor of the system. Modes are determined of e-m wave oscillation with maximum growth increment and for these modes the Umov-Poynting vector is obtained which characterizes the energy flow of e-m radiation in plasma. It is noted that in a magnetized plasma, as in an isotropic, of all e-m waves excited by the beam, quasilinear potential waves have the maximum growth increment. This enables determination of the amplitude of steady-state nonlinear waves and computation of the Umov-Poynting vector in a magnetized plasma during beam instability development. An analysis of e-m radiation is done for two cases: in dense and in rarefied plasma, and e-m energy flux is determined for both these cases. It is concluded that the interaction of a low density electron beam with magnetized plasma leads to e-m wave excitation, whose spectrum corresponds to that of linear electrostatic oscillations.

Golubev, Ye. M., N. N. Ogurtsova, I. V. Podmoshchenskiy, and P. N. Rogovtsev. Experimental investigation of the instability of a heavy-current discharge in an open tube. TVT, no. 4, 1972, 724-727.

Instability of a heavy-current discharge was experimentally investigated in an open tube with vaporizing walls, with internal diameter = 50 mm and lengths from 100 to 400 mm. The experiment was conducted in the device described by Golubev et al (ZhTF, 41, 8, 1971). The discharge was fed by a 1750-3500 μf condenser battery charged to 10 kv, which generated a single non-sinusoidal current pulse of amplitude 100-250 ka with a duration ~200 μsec. The main investigations included high-speed photographing of space-time dischar; development, oscillographic measurement of the voltage gradient of electric field in plasma column using E-probes, estimating the diameter of discharge current channel according to the erosion spot, and studying the effect of tube length and current magnitude on current stability. The space-time discharge development was observed by a high-speed photo-recorder SFR-2M with a frequency of 2×10^5 frames/sec, as seen in Fig. 1. A uniform expansion of the

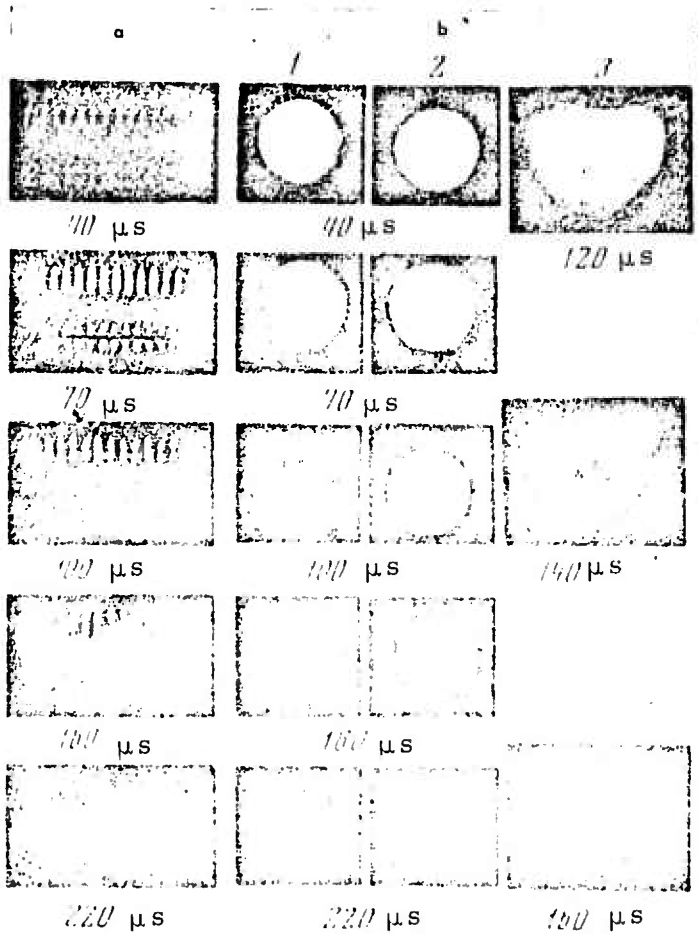

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Fig. 1. High-speed photography of a heavy-current discharge in an open tube of diameter 50 mm. Frequency = 2×10^5 frames/sec.
a - lateral projection of discharge in two mutually perpendicular planes. Dark traces are of lateral and longitudinal filamentary portions. Tube length - 200 mm, current = 200 ka.
b - Photos of discharge end. 1 - ℓ = 100 mm, I_m = 260 ka; 2 - ℓ = 400 mm, I_m = 130 ka, 3 - ℓ = 200 mm, I_m = 200 ka.

positive column at a radial velocity of 0.3-0.5 km/sec was observed during current rise. The channel reached a maximum diameter of 30±5 mm over 30-40 μsec after the current pulse, and was located symmetrically with respect to the discharge tube axis. A boundary layer of gas of thickness 5-8 mm was noted between the tube walls and the luminous positive column. Instability first occurred when the current reached maximum, and was characterized by non-uniform luminosity, diffused column boundary and constriction. Results of all investigations point towards the presence of hydromagnetic instability during heavy-current discharge in open tubes. Further photometric treatment of SFR photos obtained at λ = 400 nm showed that the intensity of plasma emission in adjacent zones of constriction and expansion was practically identical, and that the previously observed regular emission fluctuations (ZhTF, 41, 8, 1971) were not connected with change of channel geometry.

Lagunov, V. M., A. G. Ponomarenko, and L. P. Fominskiy. Formation of an intense electron beam. ZhTF, no. 9, 1972, 1947-1957.

Focusing of a 300 kev, 3 ka electron beam with a 10^{-7} sec pulse is discussed. The experimental device (Fig. 1) is described and beam parameter measurement procedures are outlined (current, electron energy spectrum, beam configuration in a focused magnetic field, and total beam energy). Simultaneous measurements were made of the cathode current i_k cathode voltage U_k, and accumulator voltage U_n during gas commutator operation. Results were used to calculate the arc resistance $R_n = \frac{U_n - U_k}{i_k} - Z$, where Z is the line wave impedance. The field emission cathode characteristics were similarly investigated and oscillograms were obtained. It was noted that the beam current i_p and cathode current i_k amplitudes were practically

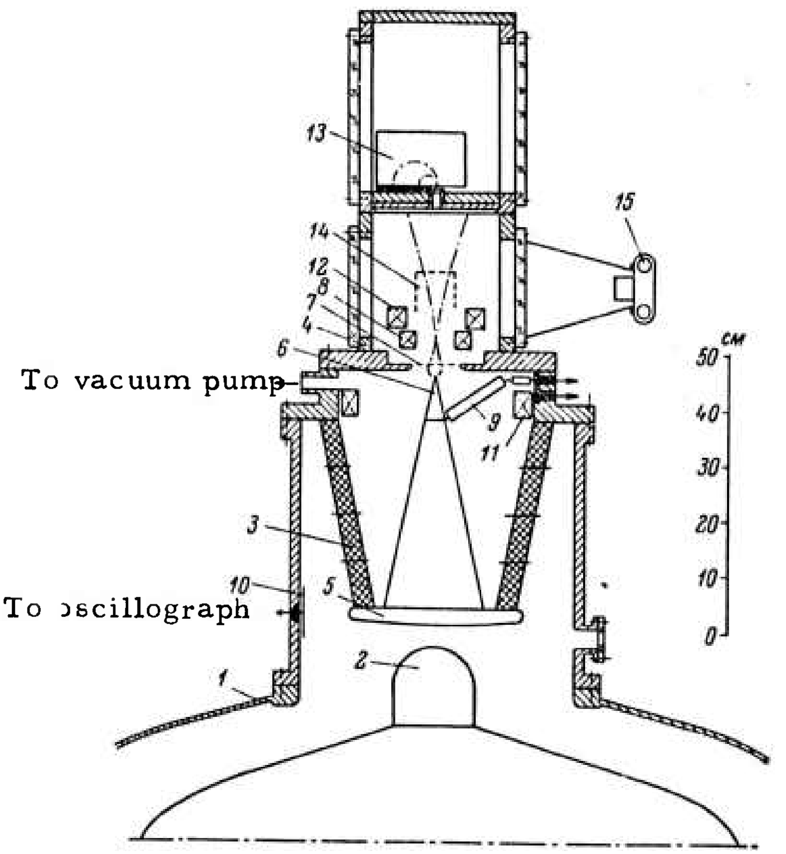

Fig. 1. Rius-1 experimental accelerator. 1 - tank; 2 - commutator; 3 - accelerating tube; 4 - vacuum chamber; 5 - support; 6 - field emission cathode; 7 - anode; 8 - coil; 9 - resistive divider; 10 - capacitive divider; 11, 12 - current transformers; 13 - magnetic spectrograph; 14 - calorimeter; 15 - camera.

independent of the number of cathode needles, and in the absence of a magnetic field, amounted to 2-3.5 ka at a cathode voltage of 250-375 kv. Magnetic beam focusing by a single-point cathode was investigated. The beam configuration was determined directly by photography and with a glass plate placed in the beam. From the results, the authors explain the beam movement in an increasing magnetic field in the following way: during the initial stage (up to 10 nsec), the beam is injected at a small radius $a_o \cong 0.05$ cm, and in a maximum field the radius $a \cong 0.2$ cm, which possibly accounts for halo formation on the glass. During subsequent stages (10-50 nsec), when the beam is injected from a plasma cloud (cathode flare) with a dimension ≅0.3 cm, the minimum beam size decreases to $\varphi \approx 1$ mm, which causes melting of the glass. Electron density in the beam reaches $4 \times 10^{13}/cm^3$. Table 1 gives experimental and calculated results (the first three lines are experimental values). The authors propose applying of the accelerator for studying the interaction of an ~1 Mev, 10 ka electron beam with plasma. Fig. 2 shows needle configurations.

B, kgs	U_g, kv	U_k, kv	I_k, ka	I_g, ka	V_n, cm/sec	ΣQ_{gen} j	Q_{calor} J
0	480	280	2.2	2	$1 \cdot 10^7$	30	—
0	630	385	3.0	3	$1.7 \cdot 10^7$	50	—
30	400	330	1.2	—	$0.55 \cdot 10^7$	21	13
0	1020	600	0.5	—	$2.7 \cdot 10^7$	—	--
0	1600	1000	30	—	$4.5 \cdot 10^7$	—	—

Table 1.

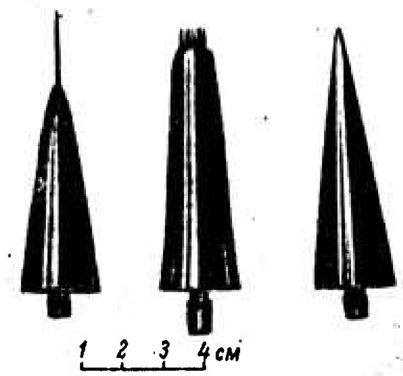

Fig. 2. Cathode needles

Smiyan, O. D., A. G. Kruzhkov, V. N. Tovmachenko, and B. N. Kolomiychuk. <u>Features of the ionization of a substance under bombardment by an intensive electron beam.</u> RiE, no. 7, 1972, 1465-1470.

The interaction of an intensive electron beam with solid targets was investigated in the ULAN-5 experimental device. The solid target was a nickel single crystal, and the beam energy was 30-70 kev. The experimental method and interaction processes are described. An intensive and complex ionization process was noted with the solid target serving as the ion source from the bombardment of a focused fast electron beam. This is shown schematically in Fig. 1. The observed high-voltage electron-ion emission phenomenon is characterized by a primary electron beam energy, ionization

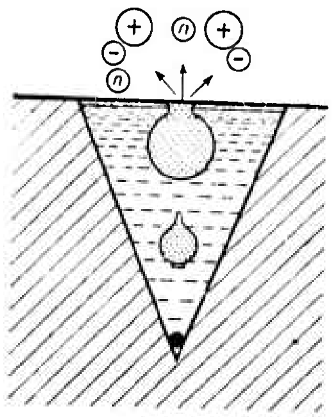

Fig. 1. Bubble formation on e-beam irradiated target.

level, ion current relationship with primary electron beam energy and density, and an ion formation process which all are significantly different from the known electron-stimulated desorption phenomenon. Conclusions from the experimental results are:

1) The hypothesis of the presence of intensive ionization during target bombardment by electron energy greater than 30 kev was experimentally confirmed.

2) The specimen ionization level increased with a rise in electron beam energy. This relationship had a peaking character for all specimens (^{12}C, ^{14}N, ^{16}O, $^{14}N_2$, $^{16}O_2$, H_2O) over the entire electron energy range investigated (30-65 kev).

3) The high-voltage electron-ion emission value displayed a linear relationship to electron beam density over the range of 1-1000 a/cm^2.

4) Curves of the ion current function during electron-ion emission intersected at a critical point for the given target material.

5) Under high-voltage electron-ion emission, almost complete ionization of the specimen occurred in the solid as well as gas phases. The ioniza contained surface sorbent impurities; the residual gas was not ionized.

6) On the basis of the emission phenomenon developed, new sources may be developed and applied in purity analyses of solids containing various admixtures.

A related study was reported recently by Smiyan (July 1972 Report, p. 60).

Pastukhov, V. P. Instability of an azimuthal relativistic electron beam with thermal dispersion. ZhTF, no. 6, 1972, 1104-1112.

The stability of azimuthal beam systems with cylindrical and ring current layers formed by relativistic electrons spinning in a magnetic field along the z-axis was studied. The electrons are characterized by thermal dispersion and a finite cross section. The finite beam width and the diffusion of Larmor centers along the system axis must be considered when investigating the stability of such systems.

The azimuthal beam corresponds to a strongly inhomogenous plasm under the condition $a_o \ll b < \rho_o$, where a_o is the dispersion of the Larmor centers (typical size of inhomogeneity); b is the Larmor radii spread; and ρ_o is the typical Larmor radius of beam electrons.

An azimuthal beam model is analyzed which is homogeneous along the z-axis, with zero net velocity along this axis. The beam space charge is compensated by cold ions. Conditions are given for neglecting the beam internal constant magnetic field for which a negligible beam density is required. Dispersion equations for system oscillations with azimuthal beams are derived from Maxwell equations. Charge and current densities generated by the wave are represented in a perturbed distribution function which expands along the small parameter a_o/ρ_o. The distribution function is determined in a linear approximation by integration along trajectories of a Vlasov linearized equation.

One of the two primary problems examined in the study is the effect of thermal dispersion on beam-induced oscillations of electromagnetic waves in vacuum. From Maxwell and Poisson equations with boundary conditions dispersion equations are derived for frequency oscillations approaching those of electron-cyclotron harmonics: $\omega_o \approx m\tilde{\omega}_{B_o}$ $(m \neq o)$ and $\omega_o \approx (m \pm 1)\,\tilde{\omega}_{B_o}$. The roots of the equations have positive imaginary parts corresponding to instabilities. Solutions are obtained under the conditions that a) $\beta_o \cong 1$, and the beam is relativistic; and b) the beam is narrow and all beam particles participate in generating the oscillations. The resulting instabilities are hydrodynamic. When the opposite condition (б) is met, which applies when accounting for the finite beam cross section, the primary contribution to $\mathrm{Im}\,\omega$ is from the resonant particles. It is shown that the azimuthal modes of oscillation are unstable: $\omega_o \approx (m-s)\tilde{\omega}_{B_o}$, $|s| \geq 1$; $s(m-s) > 0$. Formulas of increment are obtained for the cited instabilities. It is evident from the solutions that the axisymmetric HF $(m=0)$ oscillations are stable. It is qualitatively shown that, since the dispersion equation for low-frequency axisymmetric oscillations has only real roots, these oscillations are therefore stable. The second primary problem is on the oscillations from a cold dense homogenous plasma system in a conducting cylinder of radius R, with a relativistic azimuthal beam axis coincident with the system symmetry.

It is concluded that the thermal dispersion in the azimuthal beam acts as a stabilizer for oscillations at $\omega \approx m\tilde{\omega}_{B_o}$ and $\omega = (m-1)\tilde{\omega}_{B_o}$, especially in the short-wave region, but also results in oscillation instabilities at $\omega \approx (m-s)\tilde{\omega}_{B_o}$.

Kovpik, O. F., Ye. A. Kornilov, Yu. Ye. Kolyada, and Ye. V. Lifshits. <u>External high frequency modulation of electron beams and plasma heating of ions with beam instability in a magnetic trap.</u> UFZh, no. 5, 1972, 734-739.

The effect of external high-frequency modulation of electron beams on ion heating was investigated at a beam energy of 5-25 kev and a current of 1-20 a in a 1 to 3 kgauss magnetic field. The discharge chamber diameter was 20 cm. The beam was modulated at an oscillation frequency of 2800 MHz. Passive diagnostics of the plasma corpuscular radiation was used to restore the ion distribution function and compute the accelerated ion density. Fig. 1 shows ion energy distribution when external HF modulation

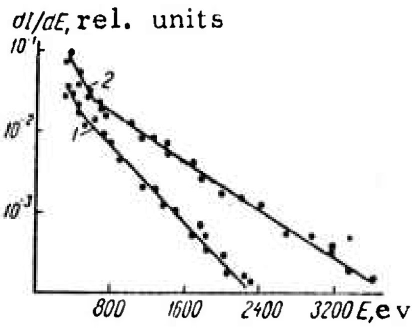

Fig. 1. HF modulation ion energy distribution. 1- unmodulated 2- modulated.

amplifies LF oscillations in the frequency zone of the lower hybrid resonance $f\sqrt{\omega_{Hi}\omega_{He}}$ (10 MHz) and at ion-cyclotron frequencies f_{Hi}(40 KHz).

The external modulation was observed to increase the number and energy of accelerated ions more effectively than by a direct increase of beam intensity. The HF diagnostics revealed that the oscillation spectrum attained a maximum amplitude in the region of 500-5000 MHz for electron-cyclotron and 0.040-30 MHz for ion-cyclotron frequencies.

Zharov, V. F., V. K. Malinovskiy, Yu. S. Neganov, and G. M. Chumak. Effectiveness of stimulating generation in an F_2+H_2 mixture by a relativistic electron beam. ZhETF P, v. 16, no. 4, 1972, 219-222.

Experimental results are discussed of the integral energy characteristics of an $F_2 + H_2$ laser pumped by an electron beam of 4 ka at 2 Mev energy and a 50 ns pulse width. Schematic elements are shown in Fig. 1. The cavity was a 1.5xl.5x5 cm copper shell cooled to 100° K by external refrigerant, so that the fluoride mixture was stable up to 600 torr, the highest tested pressure. (This is the Rius-5 accelerator).

The authors determined the energy loss in the pump beam, which was injected normal to the laser axis through a titanium separator foil (Fig. 1). It was estimated that 30% of the beam energy was delivered to the mixture. In terms of pressure the lasing threshold was 150--200 torr; output pulses were on the order of 20 μsec. Fig. 2 shows the linear characteristics of laser energy vs. pressure over the 200--600 torr test range. The laser efficiency Q_l/Q_a, where Q_l = laser energy and Q_a = absorbed pump energy, was effectively constant at 1.5--1.8 in this range. The results thus suggest some useful possibilities for e-beam triggering of chemical laser reactions.

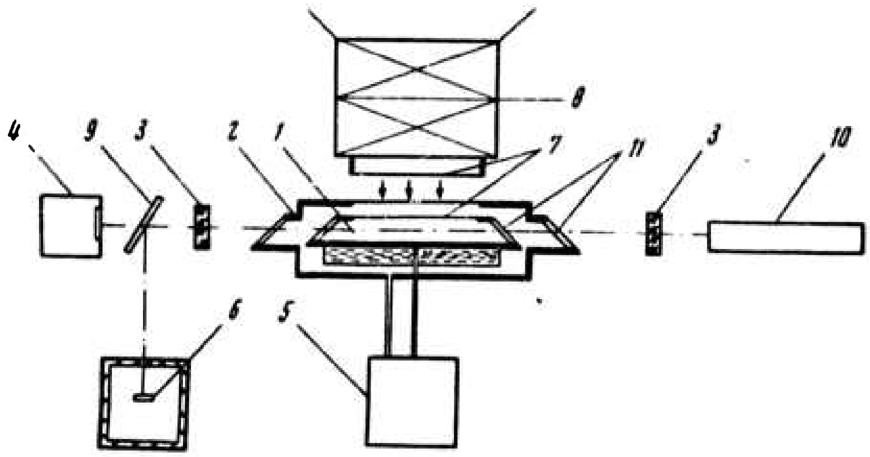

Fig. 1. E-beam pumped F_2-H_2 laser.
1 - laser cavity; 2 - outer shell; 3 - mirrors; 4 - calorimeter; 5 - gas supply; 6 - Ge-Au detector; 7 - titanium foil; 8 - accelerator magnetic lens; 9 - deflector; 10 - LG-126 alignment laser; 11 - CaF_2 windows.

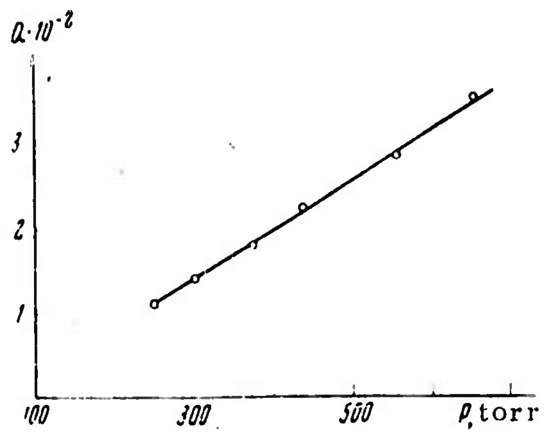

Fig. 2. Pulse energy vs. (F_2+H_2) pressure

Tkach, Yu. V., Ya. B. Faynberg, L. I. Bolotin, Ya. Ya. Bessarab, N. P. Gadetskiy, I. I. Magda, and A. V. Sidel'nikova. A plasma-beam discharge laser. ZhETF, v. 62, no. 5, 1972, 1702-1716.

The possibility of using collective interactions between electron fluxes and plasma for pumping a gas laser is experimentally studied. An electron beam with 3 a current, 40 kev energy, and 90 μs pulse duration, generated by electron gun, was injected into a plasma chamber 3 meters in length and 110 mm in diameter at a pressure of up to $2x10^{-3}$ torr. The plasma was located in a uniform magnetic field of 0.4-1.7 koe. As a result of interaction, a plasma-beam discharge is formed with electron temperatures reaching several hundreds of kev. Plasma density is 3-4 orders higher than electron beam density and its volume far exceeds the space occupied by he electron beam. Plasma temperature increases linearly with increase of electron beam intensity; in argon plasma, the temperature reaches 0.4 ev at a beam power of 800 kw and a maximum electron temperature of 100 ev.

Generation of coherent emission was observed under two condition of operation. First, in the pulsed regime, the duration of generation was small in comparison with the duration of the current pulse; these conditions were observed when the pressure was $3x10^{-4}$ to $9x10^{-4}$ torr. In the pulsed regime, generation is related to the presence of a group of hot electrons whose maximum temperature reaches 0.7-0.8 kev; with the breakdown of instability these electrons disappear. In the second case, in the region of $9x10^{-4}$ to $6x10^{-3}$ torr, a quasi-stationary regime of generation exists in the plasma chamber. This generation begins after 15 to 25 μs and ends with the termination of the current pulse. With increase of current duration the duration of pulse generation also increases, hence a transition to the stationary regime becomes possible. At pressures considered optimal for generation in a quasistationary regime the electron temperature does not exceed 10-15 ev, whereas electron density exceeds $2 \times 10^{13}/cm^3$.

The results of experiments are shown in the figures below.

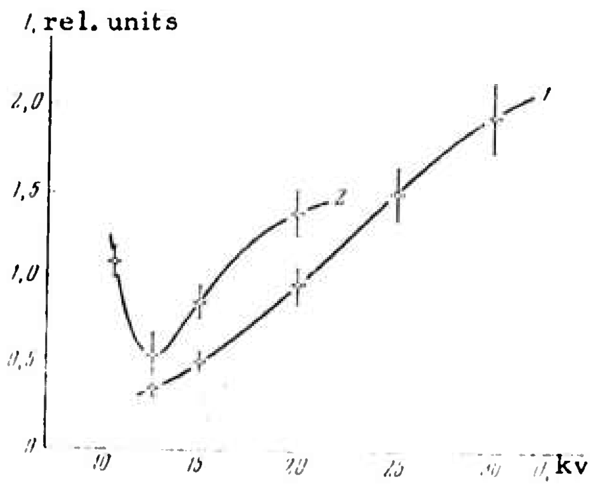

Fig. 1. Dependence of emission intensity on electron beam energy. 1- pulsed generation regime (I_{beam} = 10 a, P_{ar} = 3×10^{-4} torr); 2- quasistationary generation regime (I_{beam} = 8 a, P_{ar} = 9×10^{-4} torr).

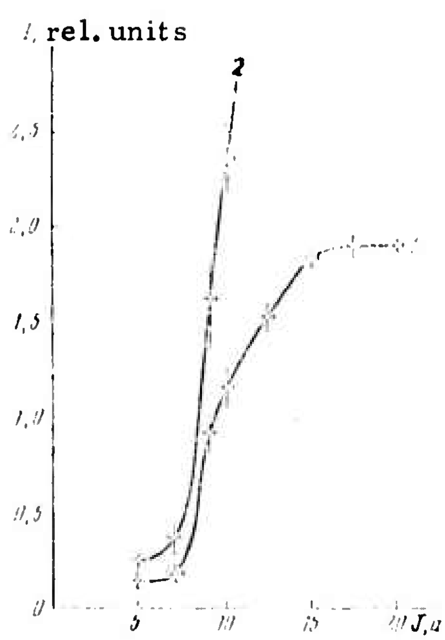

Fig. 2. Dependence of coherent radiation intensity on electron beam current. 1- pulsed generation regime (U_{beam} = 45 kv, P_{ar} = 3×10^{-4} torr); 2- quasistationary generation regime (U_{beam} = 35 kv, P_{ar} = 9×10^{-4} torr).

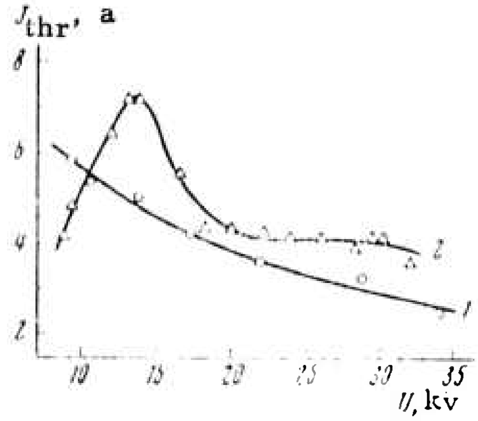

Fig. 3. Dependence of beam current threshold with its energy. 1- pulsed generation regime; 2- quasistationary regime.

The possibility of using collective processes in high-temperature plasma for pumping gas lasers is thus shown; this permits a substantial increase in the spectrum of generated wavelengths and in generating capacity. Pumping a plasma-beam discharge by relativistic electron beams with 10^{12} watt pulse intensity would be the most suitable method for obtaining generation in the shortwave optical region. Other results of this type of study were reported elsewhere by Tkach et al (December 1972 Report, p. 103).

Rudakov, L. I., V. P. Smirnov, and A. M. Spektor. Behavior of a high-current electron beam in a dense gas. ZhETF P, v. 15, no. 9, 1972, 540-544.

Tests with high-current e-beam propagation have shown that in a dielectric chamber filled with air at atmospheric pressure an electron beam (energy - 660 kev; current ≈12 ka; and pulse duration ≈40 sec [nsec?]) disintegrate within a path length of~12 cm. The length of penetration L of the beam into air decreases from 20 cm to 10 cm with a drop of pressure from 0.4 to 1.6 atm; conversely at lower pressures the value of L rises rapidly. The results are given in Fig. 1.

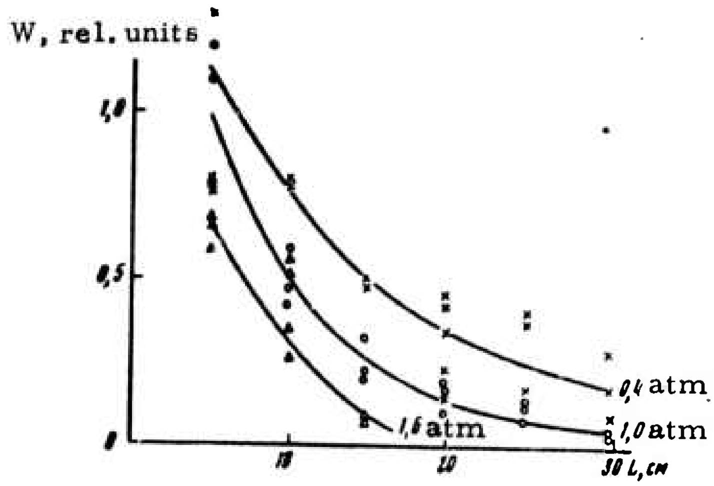

Fig. 1. Energy distribution of electron beams vs. travel and ambient air pressure. W = calorimeter reading, relative units.

A peculiar instability of the beam in a strongly dissipative medium is offered as an explanation for these effects. The dispersion equation describing the behavior of small disturbances of beam density, at the frequency of dissipation of dense plasma electrons $\nu_e \sim 4 \times 10^{12}$ sec^{-1} and a pressure of 1 atm, has the following form:

$$1 + \frac{\omega_p^2}{i\omega\nu_e} = \frac{\omega_p^2}{(\omega - k_{\parallel} u)^2} \frac{n'}{n} \left(\frac{1}{\gamma} \frac{k_{\perp}^2}{k^2} + \frac{1}{\gamma^3} \frac{k_{\parallel}^2}{k^2} \right) \qquad (1)$$

where $n' \approx 2 \times 10^{11}$ cm^{-3} and $n \approx 2 \times 10^{15}$ cm^{-3} stand for particle concentrations in the beam and the plasma, formed as a result of gas ionization by relativistic beam electrons; u is the beam velocity: $\gamma = (1 - \frac{u^2}{c^2})^{-1/2}$; and $k_{\parallel}, k_{\perp}$ are the components of the wave vector of disturbance along and across the direction of beam propagation. This equation has an unstable solution leading to bunching of the beam, resulting in retardation of the beam owing to dissipation from alternating current excited in the plasma. In addition to slowdown, a decrease in energy flux may also result from the deposition of beam particles upon the walls, caused by the increase in radial velocities from the oscillating electric field.

The limits on path length were determined to be

$$\gamma \frac{n}{n'} \frac{\overline{\Delta u}}{\nu} \leqslant L \leqslant \gamma \frac{n}{n'} \frac{u}{\nu_e} \qquad (2)$$

where Δu is the thermal scattering of beam velocities in the direction of propagation. Assuming that $\Delta u \approx 5 \times 10^9$ cm/sec, the authors obtain for L a value that is very close to that observed from the experiment in air. Since in the above phenomenon a considerable portion of beam energy may dissipate in heat, its application to collective heating of superdense plasma suggests itself.

Kovalchuk, B. M., V. V. Kremnev, G. A. Mesyats, and Yu. F. Potalitsyn. Discharge in high pressure gas initiated by a fast electron beam. IN: 10th int. conf. Phenomena ioniz. gases, Oxford, 1971, 175 p. (RZhMekh, 9/72, no. 9B156)(Translation)

Discharge properties were studied in a high pressure gas initiated by a 20 cm^2 cross-section fast electron beam. The beam penetrated through titanium foil into a 22 mm long discharge channel, filled with nitrogen at pressures from 1-16 atm. The average beam electron energy was 80 kev and the maximum energy was 180 kev. Discharge occurred in a pulsed regime and was fed either from a condenser, charged to 50 kv, or by a pulsed voltage to 250 kv, at a pulse duration of 8×10^{-8} sec. Results of measurements are plotted. Application of the electron beam eliminated discharge streamers and lowered the static breakdown voltage value.

Belan, N. V., N. A. Mashtylev, and B. I. Panachevnyy. Effect of parameters of an accelerating injector circuit with an inductive energy accumulator on plasma bunch acceleration. IN: Sbornik. Samoleto- str i tekhn. vozdushnogo flota, no. 27, 1972, 21-27. (RZhMekh, 9/72, no. 9B148). (Translation)

The acceleration of a plasma bunch in a plasma injector with an inductive energy accumulator is discussed along with the effects of accelerating circuit parameters on plasma bunch acceleration. It is shown that the mechanical energy conversion factor rises with increased energetic system parameters and decreased active resistance distribution parameters of the accelerating circuit.

Kikvidze, R. R., V. G. Kotetishvili, and A. A. Rukhadze. Discharge emission from a solid plasma during beam instability development. FTT, no. 8, 1972, 2231-2235.

The possibility is investigated of generating and amplifying e-m waves by means of an electron beam passing through a cylindrical gap in a solid specimen. The authors specifically consider a semiconductor (or semimetal) with a cylindrical gap a, through which passes a nonrelativistic monoenergetic electron beam with velocity v_o. From hydrodynamic equations for carrier motion and Maxwell's equation, a system of equations is derived defining oscillation criteria. An expression is derived for the Umov-Poynting vector connected with quasilinear wave emission, and energy flow is determined of e-m radiation in a plasma due to beam-excited waves. Steady-state wave amplitude is computed using nonlinear theory. Expressions are obtained for conversion efficiency of beam energy to lateral e-m radiation energy, and maximum efficiency is found to occur in the region $w_o a/v_o \cong 1$, when e-m radiation energy is distributed equally between beam and plasma. The authors discuss specific advantages of this system over systems with spatial excitation, for generation of powerful radiation in the centimeter and millimeter range.

Bolotin, L. I., Ye. A. Kornilov, O. K. Nazarenko, S. K. Pats'ora, and Ya. B. Faynberg. Instability of electron welding beams. ŽhTF, no. 8, 1972, 1620-1624.

This describes an experimental study of instability of electron welding beams moving through plasma generated by the beam itself, for the case in which the ratio of beam length to diameter is $L/d \gg 1$. The radius of the low density electron beam (current 5 to 100 ma under steady state conditions; energy 15 to 80 kev) was 1 cm at the end of the beam transmission through the 1500 cm long interaction sector. Within this region, by admitting gas, pressure was varied within the range of 5×10^{-3} to 10^{-5} torr.

At two points, i.e. at the exit from the electromagnetic lens and at the end of the interaction sector, the density, diameter, potential and oscillations of the beam were recorded. Spontaneous displacement of the beam along the cross-section of the chamber, beam curvature and axial oscillations in the beam were observed. Two separate oscillatory regions were recorded: 0 to 5 and 10 to 40 Mhz. High-frequency oscillations (10 to 40 Mhz) were observed not only in the beam but also outside the beam; these oscillations were sensitive to the beam current and to the pressure of residual gas. Oscillation frequency with a maximum amplitude is a linear function of the square root of gas pressure, i.e. these oscillations are produced by beam instability. The dependence of oscillation amplitude in the beam on residual gas (E_b=40 kev, I_b=40 ma) is shown in Fig. 1.

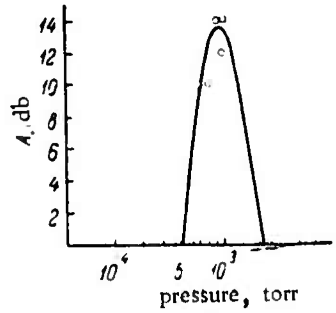

Fig. 1. Beam oscillation amplitude vs. residual gas pressure. E_b = 40 kev, I_b=40 ma.

It is evident that a pressure resonance exists for these oscillations. At low pressures plasma density is low and no beam instability develops; at high pressures, collision frequency increases, which also leads to the suppression of instability.

The critical value of the beam current leading to the development of instability is expressed by:

$$I_{cr} = \frac{\gamma^3 a^2 v_b}{2} \frac{m_e}{e} \frac{\nu_{b0}^2 \nu_{p0}}{\omega_p}, \tag{1}$$

where $\gamma = (1 - \nu_b^2/c^2)^{-1/2}$; a is beam radius: ω_p is electron-plasma frequency; and ν_{bo} and ν_{po} are collision frequencies of beam electrons and plasma electrons respectively, with the neutrals.

The low-frequency oscillation regions (0 to 5Mhz) were recorded only within the beam volume and their amplitude is lower by one order than the amplitude of high-frequency oscillations. Low-frequency oscillations are associated with a kite-type instability, the latter being the result of spontaneous radial displacement of the electron beam in any section with respect to the ion core. To better identify the type of instability, additional measurements are necessary in tracing the effect of the type of gas on oscillation frequency.

Vyatskin, A. Ya., A. N. Kabanov, and V. V. Trunev. Transmission, reflection and absorption of powerful electron beams in thin films of various metals and alloys. RiE, no. 9, 1972, 1893-1898.

Experiments are reported in simultaneously measuring the integral coefficients of transmission η, reflection r and absorption γ of powerful electron beams with a pulsed current density 1-3 a/cm^2 and initial energy of 10-35 kev in clear thin films of Al, Cu and nichrome. This is a continuation of an earlier study (Vyatskin et al, RiE, no. 12, 1971, 2332) of bombardment effects on Al alone. Simultaneous measurements of transmitted, reflected and absorbed electron currents were made in the triple-electrode collector system described in another previous work of the authors (RiE, 12, 9, 1967, 1636). Secondary electron emission was applied using highly transparent blocking grids on both sides of the specimen with a bias of-50 to-80 v. Both single-stage and multistage trigger methods were used with a pulse repetition frequency f = 5-1000 Hz and duration τ = 5-300 μsec; measurements we: taken in a pulsed beam current modulation regime. Relationships were obtained for coefficients η, r and γ as functions of film thickness, x, at initial energies of E_0 = 10, 15, 20, 25, 30 and 35 kev; results are plotted. Empirical formulas are derived and results are given in Table I. Here p is a material constant in the range $1 < p < 2.2$.

Table I. Target parameters vs. beam energy.

E_0, kev	Al; $p = 2$		Cu; $p = 1{,}65$		Nichrome; $p = 1{,}6$	
	$\alpha \cdot 10^{12}$	$\mu \cdot 10^{10}$	$\alpha \cdot 10^{7}$	$\mu \cdot 10^{7}$	$\alpha \cdot 10^{7}$	$\mu \cdot 10^{7}$
10	290	1680	69	270	82	280
15	78,5	455	23	90	29	98
20	32	187	11,3	41	11	49
25	15,3	89	7,0	26	8,2	27
30	7,5	44	3,7	14,5	5	17
35	2,3	13,4	2,5	9,5	3,2	11

Results show that within the investigated limits of initial energy and beam current density, relationships of transmission, reflection and absorption of electrons in a solid body, as characterized by empirical formulas considered, do not depend on current density; this holds true up to the moment of specimen destruction.

Vyatskin, A. Ya., and V. V. Trunev. Interaction of electrons with dielectric thin films. RiE, no. 9, 1972, 1899-1905.

In an extension of the foregoing article, the present work considers simultaneous investigation of various characteristics - transmission (η), reflection (r) and absorption (γ) coefficients - of medium energy electrons (4 kev < E_0 < 30 kev) in thin Al_2O_3 and SiO_2 films of 500-12000 Å thickness. Measurements were made on free films, so that any distorting effects of a substrate were eliminated. Surface charge effects on the specimens were also avoided by taking measurements in a pulsed regime of 1-100 µsec duration and a repetition rate of 0-10 Hz. Specimens were further coated with a 30-35 Å Al layer to secure a better surface conductivity. Al_2O_3 specimens were prepared by anodizing Al-foils,and SiO_2 by thermal deposition.

According to the experimental results, penetration, reflection and absorption characteristics of average energy electrons (4 kev < E_0 < 30 kev) in dielectric thin films of Al_2O_3 and SiO_2 are similar to corresponding characteristics for metals and semiconductors. The described method permits determination of the average lateral travel of electrons in dielectrics. Empirica expressions obtained for average travel in Al_2O_3 and SiO_2 dielectrics are also similar to those obtained for metals and semiconductors.

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5. Material Sciences

A. Abstracts

Karnaukhov, V. G. Approximate solution of wave propagation problems in visco-elastic materials. PM, no. 9, 1972, 91-96.

Wave propagation in viscoelastic materials is described by a set of nonlinear integro-differential equations

$$L(\tau, \vec{\rho}, u, u_t, u_x, u_y, u_z) = M(\tau, \vec{\rho}, u, u_t, u_x, u_y, u_z) - \varepsilon F(\tau, \vec{\rho}, u, u_t, u_x, u_y, u_z) = 0, \quad (1)$$

where u ($\vec{r}$, t) is the N-dimensional vector function, t is time, $\vec{r}$ is a space coordinate, ϵ is a small parameter, τ and ρ are the nonstationarity and inhomogeneity parameters of the medium, and L, M, and N are the functionals. Solution of (1) is shown to be possible using the asymptotic method of Luke (Proc. Roy. Soc., A 292, no. 1430, 1966), which was developed for liquids, plasma, and dielectrics. A solution in the form of an asymptotic series is obtained for harmonic perturbations in a one-dimensional nonlinear visco-elastic specimen. A set of quasilinear equations is derived in a first approximation applying Bubnov-Galerkin or Krylov-Bogolyubov methods to the wave propagation problem in a semifinite, nonlinear, viscoelastic beam. This set can be used to study the evolution of multiphase modes for nonlinear dispersive waves; e.g., the evolution of a constant length, variable amplitude wave bunch, or a constant frequency, slow modulation wave bunch. The described method may be applied to the study of wave propagation in elastoplastic, viscoplastic, and elastoviscoplastic media.

Faynberg, Ye. A., and S. E. Piterskikh. Effect of penetrating radiation on density of electrovacuum glasses. NM, no. 10, 1972, 1834-1838.

Density changes of electrovacuum glasses were studied experimentally to assess the potentially predominant effect of irradiation on the service life of the glasses when sealed to other materials in vacuum electronic devices. Glasses of varying composition were irradiated with a thermal neutron flux in a VVR-Ts nuclear reactor; A gamma ray flux from a Co^{60} source; or electrons in a 9.1 Mev linear accelerator. Irradiation in 1 and 10 Mw reactors was carried out with 4.6, 33, and 170×10^7 rad γ-radiation dosages. The gamma and electron flux intensities were ~1,000 and 1.5×10^4 rad/sec, respectively. The specimen maximum irradiation temperatures were: 110-120° (reactor), 40° (Co^{60} source), and 30-40° C (accelerator). Specimen density and length were measured over intervals of 20-30 (reactor), 2-5 (Co^{60} source), and 15-30 (accelerator) days following irradiation. Tabulated experimental data (Table 1) for the neutron-irradiated glasses show three distinct categories of glasses with density variations of over 0.5% (S49-2, S40-1, and S38-1 borosilicate glasses), 0.02-0.2% (KV, S89-6, and S87-1), and less than 0.02% (C48-3). All density variations were positive (densification).

TABLE 1

Density variations in irradiated glasses

Glass	Density variation (in %) of glasses irradiated by													
	γ- flux per dose, rad				thermal neutron flux, n/cm²						electrons per dose, rad			
	10[illegible]	10[illegible]	5·10[illegible]	10[illegible]	1,7·10[illegible]		[illegible]		[illegible]		10[illegible]		10[illegible]	
	A	A	A	A	B	A	B	A	B	A	B	A	B	A
KV	0		0	0,01	0	0	0	0,02	0,12	0,00	0		0	0
S [illegible]-1	0	0,02	0,05	0,09	0,12	0,28	1,85	*	2,07	*	0		0,18	0,15
S [illegible]-1	0	0	0	0	0,11	0,07	0,77	0,15	1,55	1,11				0,02
S 8-3	0	0	0	0		0		0		0,01	0		0	0
S [illegible]-2	0	0	0	0	0,07	0,05	0,00	0,31	1,16	1,08	0		0	0,01
S 7-1	0	0	0	0		0		0,01		0,02		0		0
S [illegible]	0	0	0	0	0	0,01	0,03	0,02	0,10	0,07	0		0	0,01

Footnote: A- relative density variations calculated from length values $((3 \Delta l / l) \times 100\%)$, B- relative density variation measured by flotation in a heavy liquid $(\Delta d/d) \times 100\%$, * denotes cracking of an irradiated specimen.

The neutron-irradiated glasses with a high B-type content (18-27%) exhibited the greatest densification, presumably because of the B^{10} (n, α) Li^7 reaction. Only the B-type glasses were sensitive to γ and electron irradiation, most probably owing to ionization. The mechanism of ionization densification, however, remains unclear. For neutron-irradiated KV quartz glass, the densification was due primarily to interaction with fast neutrons. A suggested analogy between the mechanism of glass densification by irradiation and structural stabilization by annealing was not verified by the experiment.

Grigor'yev, F. V., S. B. Kormer, O. L. Mikhaylova, A. P. Tolochko, and V. D. Urlin. Experimental determination of hydrogen compressibility to densities of 0.5 to 2 g/cm^3. Metallization of hydrogen. ZhETF P, v. 16, no. 5, 1972, 286-290.

A brief report is given on results of explosive compression tests on hydrogen in which pressures on the order of megabars were generated. A cylindrical shell was used, compressed by a surrounding explosive charge; hydrogen density was deduced from gammagraphs of the compressed volume.

The authors' results are shown in Table I, and some comparisons with earlier reported data are given in Fig. 1. Most attention is focused on the region near 2.8 Mbar, where the test results deviate noticeably from theory. The anomaly can be explained by postulating a transition to a metallic state at about 2.8 Mbar, with hydrogen density undergoing a step increase from 1.08 to 1.3 g/cm^3. Calculations put the temperature under these conditions at 7000° K, requiring a liquid state. More exactly, calculations for P > 2.8 Mbar were based on the assumption of two liquid hydrogen phases, correlated by a second-order phase trans..ion as in the case of shock-compressed liquid NaCl.

Table I. Explosive H_2 compression.

№ п/п	ρ, g/cм^3	error $\Delta\rho/\rho$, %	$\delta = \rho/\rho_k$ [1]	P, Mbar
1	0,45	12	5,1	0,37
2	0,98	17	11,0	2,63
3	1,15	18	12,9	3,24
4	1,40	21	15,7	4,40
5	1,95	40	21,9	8,00

[1] ρ_k = 0,089 /cм^3 – H2 dens..y at T = 0, P = 1 bar

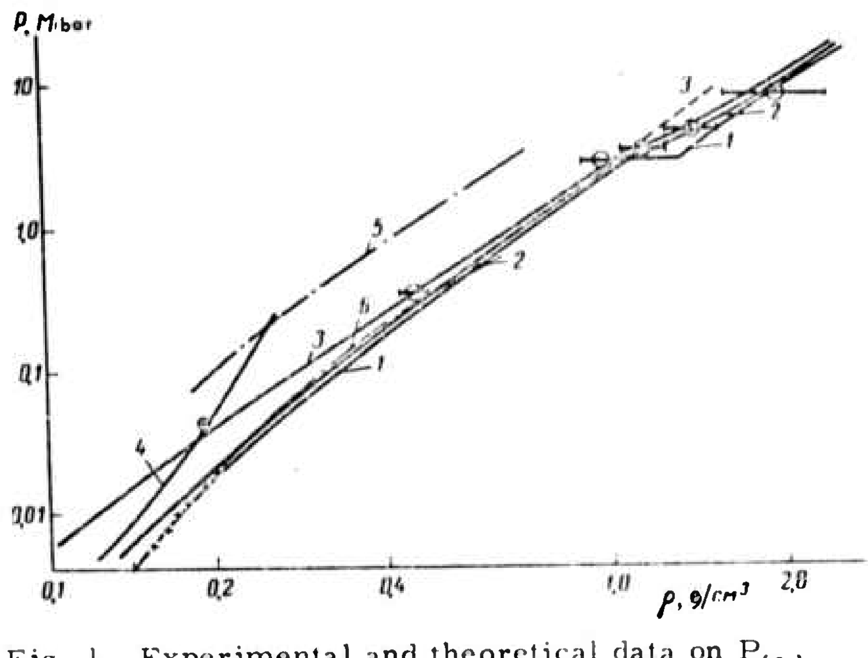


Fig. 1. Experimental and theoretical data on $P_{(\rho)}$ for hydrogen. 1- null isotherm; 2- melt curve; 3- isentrope; 4- shock adiabat calculated by authors; 5- $P_{(\rho)}$ from Abrikosov (Astron. zh. 31, 112, 1954); 6- from Trubitsyn (FTT, ..o. 7, 1965, no. 8, 1966)

⊢○⊣ indicates authors' test results

Alayeva, T. I., L. F. Vereshchagin, V. V. Gvozdev, Yu. A. Timofeyev, V. A. Shanditsev, and Ye. N. Yakovlev. <u>Unit for measuring electron resonance spectra under quasihydrostatic pressures to 100 kbar</u>. PTE, no. 5, 1972, 206-208.

A high-pressure unit (Fig. 1) is described which was designed to study electron resonance spectra in the SHF range (3 cm) at pressures to

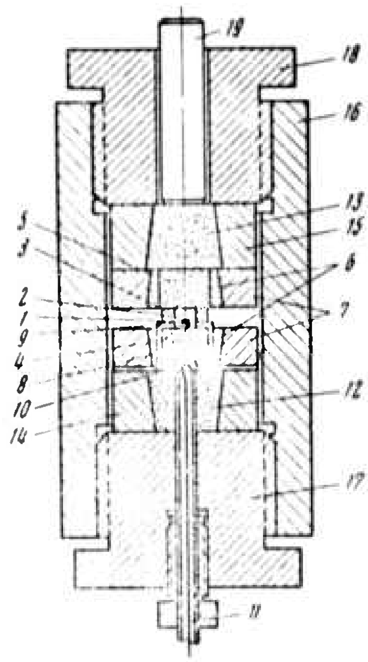


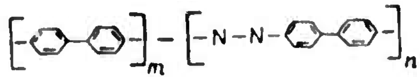
Fig. 1. High-pressure unit: 1- specimen, 2- AgCl or In pressure-transmitting medium; 3- pyrophyllite or talcum tablet; 4 and 5- bottom (resonator) and top ceramic dies; 6, 7, 14 and 15- supporting rings; 8 and 9- copper layers; 10- resonatc cavity; 11- coaxial cable; 12 and 13- truncated ceramic cones; 16- high-pressur chamber; 17 and 18- clamp nuts; 19- plunge

100 kbar and temperatures from liquid He to 400° K. Pressure in the medium is set at a given value using the clamp nut (18). After the pressure is released, the high-pressure chamber is transferred into a magnetic field and connected to the spectrometer through the cable(11). The chamber was calibrated for pressures corresponding to Bi III - Bi IV transition. Since the unit is self-

contained, measurements can be made at various temperatures, in a magnetic field, and with different spectrometers. In a study of the ferromagnetic to paramagnetic transition in CrTe, the Curie point shift was found to be $(6.0 \pm 0.4)^{\circ}$ K/kbar versus the $(6.2 \pm 0.1)^{\circ}$ K/kbar value from electrical resistance measurements.

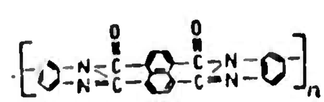
Liogon'kiy, B. I., A. A. Berlin, G. M. Shamrayev, P. P. Misyavichyus, and A. N. Machyulis. Ablation of heat-resistant polymers. 2. Ablation resistance of polyazophenylene and poly (naphthoylene-bis-benzimidazole)-base composites. IN: Trudy AN LitSSR, Seriya B, v. 4 (71), 1972, 123-130.

The preparation and testing are described of polymer composites based on the polyconjugated compounds



(PAP)

and



(PNB).

Earlier studies revealed that PAP and PNB are highly ablation-resistant. It was anticipated that structurally modified PAP and PNB would exhibit even higher ablation resistance under more extreme conditions. The compounds were modified by copolymerization with polymerizable, relatively low-molecular weight monomers, such as m-phenylene-bis (maleimide) (MPB), 4, 4'-diphenylmethane-bis (maleimide) (DMD), and m-tolylene-bis (maleimide) (MTD). Ablation-resistance tests at 400-700° C in an air stream indicated that the ablation velocity A_v of the PAP + MPB and PAP + DMD composites is much lower than that of pure PAP. The surface layer destruction proceeds by thermal oxidation, followed by mechanical erosion. The optimum MPB and DMD concentrations were 10 and 5%, respectively. The PAP + MPB or DMD + 25-50% asbestos composites exhibited an even higher ablation resistance, owing to the reinforcement effect and the electron acceptor property of asbestos. A significant increase in ablation resistance of the PAP-base ternary composites was attained by preheat treatment at 400° C in an Ar atmosphere. It was established that the introduction of 10% MPB or MTD increased the PNB ablation resistance owing to the plasticizing effect of bis-maleimides. In this case, the $A_v(t)$ kinetic curves were monotonic, in contrast to those of the PAP-base composites. The PNB + 10% MPB composite had the highest ablation resistance, even under the most extreme conditions of 700° C and $p = 1.5\ kg/cm^2$.

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6. Atmospheric Physics

A. Abstracts

Zuyev, V. Ye. Laser probing of the atmosphere. Priroda, no. 10, 1972, 86-93.

The state-of-the art of high spatial and time resolution, high power pulsed laser sounding of the atmosphere is reviewed. Data processing techniques and cost effectiveness of laser sounding systems are mentioned. Brief accounts are given of aspects of laser sounding, including: fundamental principles and applications of optical radar systems, sounding of tropospheric and stratospheric aerosols using single pulse emission to heights of 30-50 km, measuring atmospheric transmissibility in vertical and angular directions, cloud sounding, atmospheric pollution monitoring, as well as measuring gas concentration and other atmospheric parameters. The author also evaluates laser sounding research and development trends, and foresees the development of multichannel systems and single-value data processing algorithms. Powerful, high pulse rate frequency lasers with tunable and fixed frequencies will be introduced which will generate pulses of tenths of nanosecond duration, ensuring good spatial resolution.

In the next five years, large-scale production is anticipated of optical meteorological radars designed specifically for precise measurements of lower cloud boundaries and atmospheric transmissibility in angular directions and for quantitative analysis of atmospheric pollution. Complex problems will likely be resolved in connection with atmospheric sounding of the concentration, refractivity and particle size spectra of aerosols, along with studies of atmospheric turbulence structure and wind direction and velocity. Laser sounding equipment on-board orbiting space stations will be used, comprising second generation optical meteorological radar systems with real-time data processing and transmission of graphical or digital data on atmospheric properties at fixed altitudes to ground-based computer centers. Some characteristics and photos of currently used probe systems are given and discussed.

Kon, A. I., and V. I. Tatarskiy. Theory of partially-coherent light beam propagation in a turbulent atmosphere. IVUZ Radiofiz, no. 10, 1972, 1547-1554.

Equations for sources of partially-coherent emissions in a turbulent medium are described and the effect of the source coherency level on light beam characteristics is calculated. An effective radius of coherency characteristic ρ_{eff} is found which determines the angular beamwidth. This characteristic also has a direct relationship in deriving the interference pattern when phase-amplitude corrections are not used. Formulas are given for ρ_{eff} behavior in a turbulent medium.

A relationship for beam axis mean intensity is presented in Fig. 1 for partially and fully coherent sources as a function of the radius of sourc coherency ρ_k/a, where a = characteristic beam size. When the inequalities $\mu_{coh} >> 1$, $\mu >> 1$ are calculated, the asymptotic formula given by one of the authors (Tatarskiy, ZhETF, 56, 6, 1969, 2106) is valid for both cases and the mean intensities for coherent and incoherent sources are similar; that is, the mean intensities for $\mu >> 1$ are not dependent on the source coherency level.

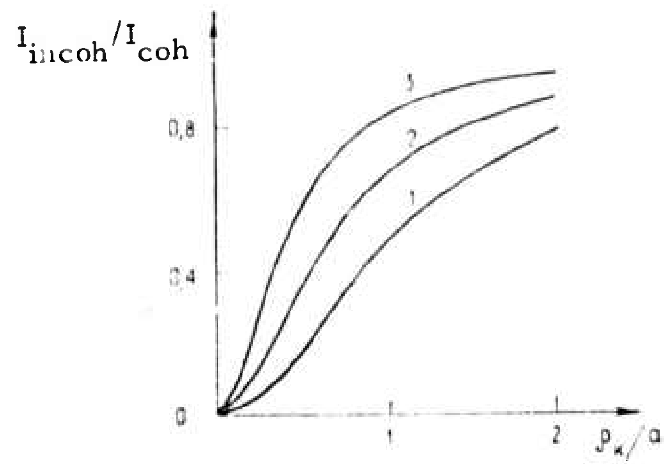

Fig. 1. Beam axis mean intensity relationship for partially and fully coherent sources. Curve 1- nonturbulent medium, 2- $\mu_{coh} = 3$, 3- $\mu_{coh} = 10$.

Klyatskin, V. I., and A. I. Kon. Markov random process approximation of shift of spatially-bounded light beams in a turbulent medium. IVUZ Radiofiz, no. 9, 1972, 1381-1388.

A brief review is given of recently published analyses which give more or less rigorous expressions for behavior of optical beam shift in a turbulent medium. Following this the authors derive expressions for beam center of gravity shift over an arbitrary path length, using a model proposed by Tatarskiy (AN SSSR, otdel. okean., fiz. atmosf. i geogr. Preprint, 1970). The result is presented in the form of integrodifferential equations whose solution yields the mean square value of the position vector of optical center $< \rho_c^2 >$, in terms of propagation path parameters. In this argument the fluctuating component of dielectric constant $\epsilon_1 (x, \rho)$ is assumed to be defined by an approximate Markov random process, with $< \epsilon_1 > = 0$. The beam variation is alternately expressed in terms of angular shift $\sigma^2 = < \rho_c^2 >/x^2$ rather than position shift; solutions for both near- and far-field are given.

Rozenberg, V. I. Rasseyaniye i oslableniye elektromagnitnogo izlucheniya atmosfernymi chastitsami (Scattering and attenuation of electromagnetic radiation by atmospheric particles). Leningrad. Izd-vo Gidrometeoizdat, 1972, 348p. (RZhF, 9/72. no. 9Zh228 K). (Translation).

The scattering and attenuation of submillimeter, millimeter, and centimeter waves is examined using an arbitrary set of physical structure and atmospheric property discriminants. Allowance is made for multiple particle reemissions. Emphasis is given to permittivity, radar and radiophysics characteristics, and algorithm construction and computer programming. The book is of interest to specialists in radio meteorology, radar, communications, radio astronomy, and radio physics, along with undergraduate and graduate students in these fields.

Klyatskin, V. I., and V. I. Tatarskiy. Statistical theory of light propagation in a turbulent medium (Review). IVUZ Radiofiz, no. 10, 1972, 1433-1455.

Results from the literature are interpreted of attempts to derive equations describing large fluctuations in wave fields, based on a diffuse random process approximation of wave propagation in a heterogeneous medium. The approximation yields closed equations for field moments which are adequate in a region of large fluctuations and an Einstein-Fokker equation for the field characteristic functional.

A stochastic equation is described for wave propagation in a random medium and several precise corollaries are introduced. A mathematical model is examined in which it is feasible to disregard the longitudinal radius of the permittivity correlation in relation to all of the longitudinal scales in the problem. This assumption, an equivalent substitution of the refractive index real correlation function for the longitudinally-directed delta function, yield a closed integral equation for all wave field moments. A Gaussian probability distribution of refractive index fluctuations is also assumed throughout. This allows reduction of the integral equations to differential equations and shows that the field characteristic function satisfies an Einstein-Fokker equation, permitting the wave propagation to be considered as a diffusion process. A method of successive approximations is presented for solving the wave propagation stochastic equation; the first approximation is the cited diffusion approximation. While determining the applicability limits of the diffusion approximation, the second approximation reveals that this approximation is valid for regions of strong field fluctuations. An example is given of calculations of the mutual coherence function and results are compared with experimental data. Phase-amplitude characteristics of light waves are also reviewed.

Light propagation in a turbulent medium is described using an approximation of geometric optics. The description covers beam diffusion in random heterogeneous media and light wave phase amplitude fluctuations.

Conclusions are discussed in terms of a theory of light propagation in a turbulent atmosphere using a quasi-optics parabolic equation which is valid when backscattering is ignored. The refractive index at an angle, $\theta \sim \lambda/l_0$, is of the order of 10^{-4}-10^{-5} for light scattering in turbulent fluctuations which contain the major portion of the scattering field. Since the atmospheric permittivity fluctuations are also small ($\delta\epsilon \sim 10^{-6}$), light backscattering in turbulent inhomogeneities can usually be ignored. An exception to this condition is likely for millimeter waves but in this case the deviation is still negligible.

The small scattering angle however results in strong scattering and incident wave interactions; notwithstanding the low $\delta\epsilon$, this effect produces powerful field fluctuations. Calculations based on perturbation methods are consequently inapplicable. The proposed theory relies on the smallness of the characteristic longitudinal scale of inhomogeneity which is analogous to the nonequilibrium kinetic theory of gases in which th brevity of the molecular interaction time is used to plot the expansions. The proposed theory, although it is dependent on permittivity fluctuations, shows excellent promise for calculations of the real atmosphere over long distances. The theory requires complex numerical analysis but overcomes the difficulty met when using the method of smooth perturbations in calculating the light field in a region of strong fluctuations.

Georgiyevskiy, Yu. S., and G. I. Gorchakov. Relationship of linear polarization level of atmospheric light scattering to beam attenuation in the infrared region. FAiO, no. 10, 1972, 1098-1099.

Factors supporting a correlation between attenuation in the infrared region and the linear polarization level of light scattering p in the visible spectrum are discussed, and simultaneous measurements of aerosol attenuation spectra and the angular dependence of the scattering matrix are described. The ground layer spectral measurements were recorded in the vicinity of Zvenigorod in October 1970. The simultaneous angular dependence measurements were made at a beam wavelength of λ = 550 nm. The distance between the beam scattering matrix measuring site and the spectral transmission path was about 100 m. Measurement characteristics emphasized were: 1) $\sigma = \sigma(\lambda = 2.2\,\mu)$, the value of aerosol attenuation which is equivalent to the scattering coefficient owing to the low absorption of water and water vapor in the spectrum region under consideration; 2) $p_1 = p(\Phi = 100$ deg$)$, the linear polarization level for the light scattering angle Φ = 100 deg which optimally represents the relationship $p(\Phi)$ under conditions of haze; 3) $p_2 = p(\Phi = 140$ deg$)$, the linear polarization level for the light scattering angle Φ = 140 deg (under the conditions of thick haze the greatest variations in the relationship $p(\Phi)$ occur in the vicinity of a rainbow).

Simultaneous measurement data for 12 nights are plotted in Fig. 1.

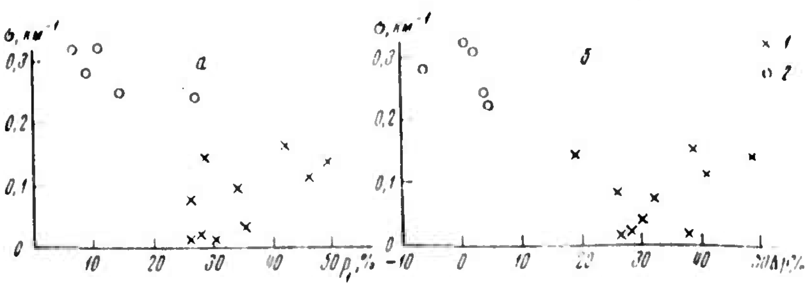

Fig. 1. Correlation between the coefficient of aerosol scattering (attenuation) σ (λ = 2.2 μ) vs the linear polarization level of light scattering for a 100 deg scattering angle (a), and based on the difference in values of the linear polarization levels at 100 and 140 degs $\Delta_p = p_1 - p_2$. 1- haze. 2- thick haze

Preliminary conclusions are that aerosol attenuation at a beam wavelength $\lambda = 2.2\ \mu$ is comparatively less ($\sigma < 0.15\ km^{-1}$) in haze and more ($\sigma > 0.2\ km^{-1}$) in thick haze. Based on the difference in values of the linear polarization level for scattering angles of 100 and 140 deg, periods of haze and thick haze are clearly discernible, permitting an evaluation of aerosol attenuation characteristics in the infrared region.

Yeremin, B. G., A. G. Litvak, and B. K. Poluyakhtov. Observation of thermal self-focusing of electromagnetic waves in plasma. IN: 10th International Conference on Phenomena of Ionized Gases, Oxford, 1971, 351. (RZhMekh, 9/72, no. 9B355) (Translation).

The thermal self-focusing of electromagnetic waves was investigat in a vacuum chamber in which a horn transmitter with lens had been inserted coupled to a magnetron oscillator through a power divider. The inner chamber was shielded by an absorber. The open end of a waveguide, serving as the receiving antenna, was bidirectionally rotated to record the electric field distribution in the antenna focal plane. Plasma was injected into the chamber from a coaxial source. Receiving and transmitting antenna relationships were examined as a function of plasma density under varying transmission outputs. At a near critical plasma density and a power level P > 35 w, the receiving antenna signal was stronger in comparison with non-plasma transmissions. This is explained by the nonlinearities resulting from the ohmic heating and subsequent drift of charged particles from the HF field region.

Sobolev, V. V. Rasseyaniye sveta v atmosferakh planet (Light scattering in planetary atmospheres). Moskva, Izd-vo Nauka, 1972, 336p. (RZhF, 8/72, no. 8D954 K) (Translation).

A theory of radiative transfer from nonisotropic scattering is developed. Fundamental problems are considered of multiple light scattering in an atmosphere comprising plane-parallel layers illuminated by parallel beams.

Yakushkin, I. G., and V. A. Permyakov. Reflection of plane TM-waves from an inhomogeneous plasma half-space. IN: Trudy Moskovskogo energeticheskogo instituta, no. 100, 1972, 14-21. (RZhF, 9/72, no. 9Zh139) (Translation).

The effects are studied of strong resonance absorption of TM-polarized electromagnetic waves impacting on an inhomogeneous plane-stratified plasma layer in an area of zero permittivity. The wave equation is solved by exponential power series and phase integral methods. Results are applied to a linear layer problem with an arbitrary gradient value. Additional results are presented of computerized calculations of reflection coefficients using the exponential power series method. The coefficients are compared with calculations of various limiting cases.

Liberman, M. A., and A. T. Rakhimov.
Theory of nonlinear propagation of electromagnetic waves in weakly-ionized plasma.
ZhTF, no. 9, 1972, 1799-1803.

Normal propagation is analyzed of an electromagnetic wave whose frequency ω is lower than the frequency of electron collision with neutrals ν, but $\omega \gg \delta\nu$, where δ is the amount of energy transferred during the electron-neutral collision into the half-space $x > 0$, filled with weakly ionized plasma. Because the plasma is weakly ionized, coulomb collision is disregarded and the plasma is considered to be quasi-neutral, i.e.

$$r_D |\mathrm{grad}\, E| \ll |E|. \tag{1}$$

where r_D is Debye radius. The structure of the plasma electric field and the electron temperature are determined by solution of the wave equation for E,

$$\frac{d^2 E}{dx^2} + i \frac{4\pi e^2 n_e(|E|)}{mc^2} \frac{\omega}{\nu} E = 0. \tag{2}$$

This solution neglects displacement currents and also those terms that are small in conductivity with respect to ω/ν. The relationship $n_e(T_e)$, if $I/T_e \gg 1$, is then given by

$$n_e(T_e) = f(T_e) \exp\left(-\frac{I}{T_e}\right). \tag{3}$$

Other physical values in the plasma are determined from the temperature values

Two cases are analyzed: propagation of a strong wave, which can cause electron temperature variation, and the structure of a weak field ($|E| \ll \epsilon$) in a theoretically nonequilibrium plasma. The nonlinear mechanism discussed is generally held to apply for $n_e = 10^{12}$--$10^{14}/cm^3$, when $n_0 \cong 10^{19}/cm$ and T_e is on the order of a few ev.

Feygel'son, Ye. M., M. S. Fuks-Rabinovich, and A. M. Yaglom. International conference on parametrization of small scale atmospheric processes. Leningrad, 20-27 March, 1972. FAiO, no. 11, 1972, 1235-1237.

A brief review is given of the title conference, whose main purpose was to investigate new approximate methods for modelling small-scale atmospheric processes, i.e. on the scale of 500 km or less. The need for this stems from the insufficient present knowledge on small scale phenomena and from computer limitations, which together make direct numerical modelling prohibitively laborious.

The 50 conferees representing 11 countries were divided into eight working groups to study possible modelling approaches for the following categories: convection, clouds and precipitation; radiation processes; the surface boundary layer; medium-scale circulation; turbulent processes; the upper boundary layer and propagation of gravity waves; hydrological processes in continents and sea ice; and interactions of the atmosphere-ocean interface.

The results were presented as working papers, which are only generally described here and without attribution to specific contributors. However, it is planned to disseminate the results soon in serial publications of the Main Geophysical Observatory in Leningrad.

Golubitskiy, V. M., T. M. Zhad'ko, and M. V. Tantashev. Effect of optical radar geometric parameters on the applicability of the single-scattering approximation. FAiO, no. 11, 1972, 1226-1229.

Monte Carlo method calculations are used to determine the applicability limits of the single scattering approximation as a function of the optical radar distance from the scattering layer, the beam penetration depth into the layer, and the optical radar geometric parameters.

The laser beam, with a divergence of 2ψ, arrives normal to a cloud, defined as a seminfinite uniform scattering boundary layer located at a distance h from the source, expressed in optical thickness units: $h = \frac{3.91}{S_M} H$

where S_m is the meteorological visibility range in the cloud, and H is the geometric distance from the pulse source to the boundary layer. A 2φ field of vision detector is situated on an axis parallel with the pulse source. The pulse source-detector base, the laser beam diameter at h = 0, and the detector input pupil are assumed to be of infinitely small size.

The calculation time resolution factor is: $\Delta\tau = \varepsilon c \Delta t = 1$, where τ is the emission path length in the medium and ϵ is the attenuation factor. The corresponding average penetration depth into the medium is: $\Delta x = \Delta\tau / 2 = 0{,}5$. Scattering properties taken from the literature are typical of a cloud indicatrix at $\lambda = 0.7\mu$. The probability of quantum survival is $\Lambda = 1$.

A relationship $(\eta_2(x)/\eta_1(x))$ is derived for the contribution of single and double scattering radiation to the detector signal amplitude as a function of the penetration depth x of the laser beam into the medium. Modified local estimates are discussed based on trajectory division into two classes at sm: angles of ψ and φ for two scattering events. Class 1 applies to primary scattering into the front of the hemisphere (forward) and secondary scattering to the hemisphere rear (back); class 2 is characterized by primary backscattering and secondary forward scattering.

Results are plotted in Figs 1-4. For Fig. 1 when the applicability conditions of the single scattering approximation are assumed to be $\eta_2(x)/\eta_1(x) < 0.2$, the maximum penetration for all h, except the smallest value h = 0.1, falls within 0.25 - 0.75. The calculation results for a narrower field of vision plotted in Fig. 2 indicate an approximate agreement of the $\eta_2(x)/\eta_1(x)$ curves for various ψ and φ, but for ψh = const. The agreement should be closest at smaller x and greater h. The validity of the agreement can b seen in Fig. 3. Fig. 4 shows the effect of reducing the angle of radiation divergence. Results for the variants $2\psi = 2{,}5'$, $2\varphi = 10'$ и $2\psi = 2\varphi = 10'$ vary by no more than 20 - 30%.

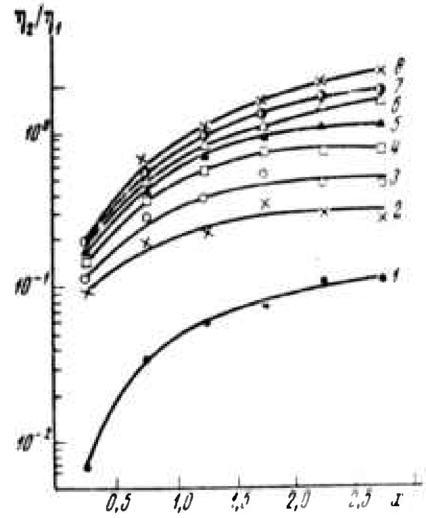

Fig. 1. Relationship of $\eta_2(x)/\eta_1(x)$ for one and two-dimensional radiation scattering of signal returns from a cloud.

$2\psi = 2\varphi = 10'$; $h = 0.1$ (1), 5 (2), 10 (3), 20 (4), 40 (5), 80 (6), 160 (7), 1000 (8)

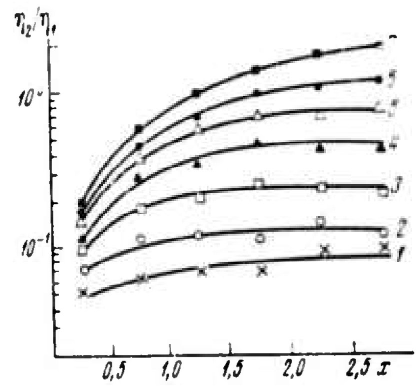

Fig. 2. Relationship of $\eta_2(x)/\eta_1(x)$ at

$2\psi = 2\varphi = 2.5'$; $h = 5$ (1), 10 (2), 20 (3), 40 (4), 80 (5), 160 (6), 1000 (7)

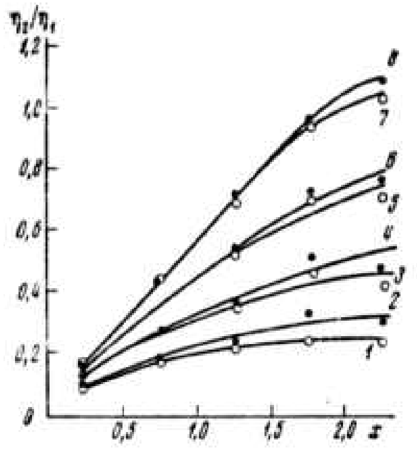

Fig. 3. Relationship of $\eta_2(x)/\eta_1(x)$ at $2\psi = 2\varphi = 2{,}5'$; $h = 20$ (1), 40 (3), 80 (5), 160 (7); $2\psi = 2\varphi = 10'$; $h = 5$ (2), 10 (4), 20 (6), 40 (8)

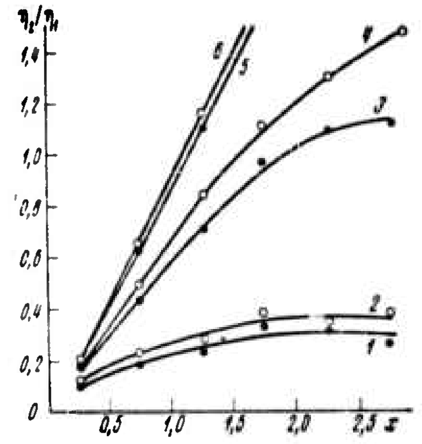

Fig. 4. Relationship of $\eta_2(x)/\eta_1(x)$ at $2\psi = 2\varphi = 10'$; $h = 5$ (1), 40 (3), 1000 (5); $2\psi = 2.5'$; $2\varphi = 10'$; $h = 5$ (2), 40 (4), 1000 (6)

Zuyev, V. Ye. Propagation of electromagnetic optical waves in earth and planetary atmospheres. VAN, no. 8, 1972, 18-24.

Theoretical and experimental atmospheric wave propagation studies using laser technology at the Institute of Atmospheric Physics (Siberian Department, Academy of Sciences SSSR) are summarized. The studies focus on the atmospheric propagation characteristics of monochromatic, polarized, coherent radiation.

Two high resolution laser spectrometers developed at the Institute are described. One of the spectrometers uses a 3.39μ single mode stabilized He-Ne laser. Radiation frequency scanning is accomplished by placing the laser in a transverse magnetic field, with the shift of the generated frequency being proportional to field strength. This spectrometer was used to obtain an undistorted individual methane line shape as well as its dependence on pressure and temperature. The center shift of this line, owing to pressure variations, was identified and measured to be 10^{-5} cm^{-1}/torr.

The second laser spectrometer incorporates electrooptic scanning of a ruby laser pulse spike structure with simultaneous precise measurements of the wavelength and intensity of each spike entering the absorbing medium. This spectrometer yielded an almost total resolution spectrum of atmospheric gas absorption within the ruby laser output range. A total of ten absorption lines were recorded from an ~1 cm^{-1} segment width of the spectrum. Eight of these were initial observations.

A broad range of laser radiation absorption measurements under actual environmental conditions have also been made by Institute researchers. The experimental studies are performed simultaneously with theoretical analyses of ultrahigh resolution absorption spectra of atmospheric gases. A theory was developed which, taking into account the effects of intramolecular and intermolecular interactions, defines energy levels, center positions, intensity, and absorption line halfwidth; and on this basis calculates the spectral rate of the monochromatic absorption coefficients in rotational-vibrational and purely rotational line spectra of atmospheric gases.

Experimental and theoretical findings have been used to solve the problem of determining optical wave scattering coefficients from aerosols in the ultraviolet, visible, and infrared regions with allowance for actual spectra dimensions, the concentration and complexity of the particle refractivity index, or particle chemical composition. Using an approximation method, this problem has been solved for spherical particles. The approximation method was verified for water clouds, fog, mist and rain.

The research program at the Institute on factors of background noise generation from scattering has produced criteria for quantitative analysis of the optical thickness of scattering media in which the noise background magnitude reaches a predetermined value at all possible angles of source divergence and detector field of vision. The feasibility has been demonstrated of using laser sources to transmit data through broad optical thicknesses of the scattering media.

A theory was developed on the effect of high power, directional pulsed and c-w optical radiation on single particles and polydispersed aerosols, which enables theoretical predictions of the feasibility of illuminating clouds and fog by high power optical radiation from either full or partial particle vaporization. The theory suggests that the drop radius under pulse effects would equal zero only at the critical temperature when the pulse duration is less than 10^{-4} sec. If the particle energy absorption is sufficient to increase the temperature to the critical point or higher a particle explosion is likely to occur when the water vapor at high pressures collides with the air and forms a compression wave.

Experiments confirmed theoretical computations on the evaporation of water particles; the partial illumination of water fog was also examined. It has been determined that the brightness level is not a function of particle concentration, but of the illumination itself under the continous effect of radiation propagation at a specific velocity, depending on the wavelength, the radiation power density, and the microstructural parameters of the clouds and fo

A test instrument system has been developed to study fluctuations in a turbulent atmosphere. Qualitative data have been obtained on fluctuation intensity, angle of arrival, beam cross section and beam deflection over an extended path in the atmospheric boundary layer and in an oblique direction. An integral component of the instrument system is a laser phase meter capable of measuring the phase differences of two optical waves with an accuracy to 0.1 rad.

Work in constructing algorithms for processing of data acquired by laser atmospheric probes is also mentioned.

Yakovets, A. F. Feasibility of receiving narrow pulses from ionospheric return. GiA, no. 5, 1972, 857-863.

The feasibility is analyzed of receiving short duration probe signals, assuming that the signals are correlated with propagation parameters of the medium. Expressions are formulated for distortion-free reception of narrow pulses from ionospheric returns.

A parabolic model of the ionosphere is described having a layer half-thickness of 100 km and a critical frequency f_{cr} of 10 MHz. The terrestrial magnetism intensity H = 0.

Fig. 1 illustrates a relationship for a half-width input pulse τ_{Bx} and a frequency retuning rate 2γ to a half-width pulse derived for the ionospheric return of various central frequencies (f_o) of probe pulses. The graph shows that ionospheric "effectiveness", n, increases as $f_o \rightarrow f_{cr}$. A decrease in probe pulse duration leads to increased pulse half-width and reduced n.

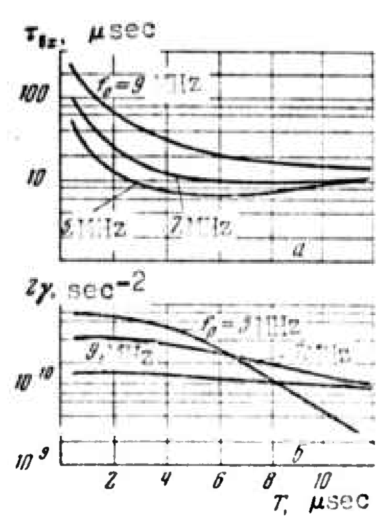

Fig. 1. Relationship of a half-width input pulse and a frequency retuning rate to a half-width pulse for ionospheric return of probe pulse central frequencies.

Formulas are given for ionospheric propagation of a constant width probe pulse with a linearly-variable pulse carrier frequency.

Analysis results show that, in terms of ionosphere dispersion properties, it is feasible to receive narrow pulses from ionospheric returns. Linear intra-pulse frequency modulation is required, along with the generation of higher frequencies prior to lower frequencies. The retuning rate is determined by both the propagation medium parameters and the duration of input and output pulses. For a complex probe signal of constant duration, the ionosphere acts as a resonance system; this system at the resonance $2\gamma = 2\gamma_{cr}$ effectively shortens the input pulse duration.

B. Recent Selections

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7. Miscellaneous Interest

A. Abstracts

Melkov, G. A. Induced shf oscillations in an open dielectric resonator. RiE, no. 10, 1972, 2027-2034.

A quasistationary solution is obtained for oscillation excitation in a dielectric element placed symmetrically in a waveguide. The theoretical model used assumes the resonator to have an $\epsilon >> 1$, and that the waveguide walls have a negligible effect on resonator behavior. Experimental confirmation of the theory was obtained by means of a rectangular rutile element with f_o = 8950 MHz placed in a standard 3 cm waveguide, propagating in the range of 1 mw to 1 watt. Resonator response was determined by spin wave excitation in a small YIG probe inserted into the resonator of an E-field minimum. Resonator Q was determined to be about 2000. The dynamic response agreed closely with theory, as shown in Fig. 1.

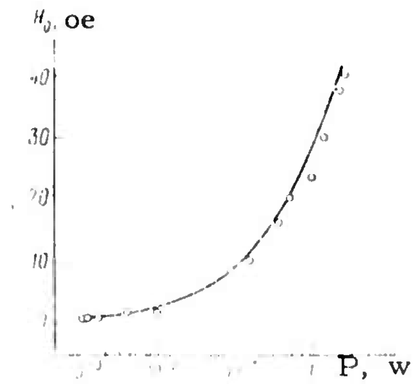

Fig. 1. Resonator magnetic field vs. waveguide power. Solid line = theoretical.

Borovich, B. L., V. S. Zuyev, V. A. Katulin, O. Yu. Nosach, Ye. L. Tyurin, and V. A. Shcheglov. Light pulse propagation in a moving two-level absorption medium. IN: Sbornik. Kvantovaya elektronika, no. 8, 1972, 88-89.

A theoretical analysis is presented of the impact of a random time form pulse $I_o(t)$ radiation source moving along the x-axis with a two-level absorption medium, which is in resonance with the source. The absorption medium interacts with the source at a constant velocity $v << c$. A solution is presented for the transfer equation with corresponding initial and boundary conditions. This solution identifies fundamental propagation characteristics of the "brightening" wave in a moving medium. It is shown that $v = v_o = 2I_o/N_o$ is the boundary of two states of propagation of brightening waves, in correspondence to the specific values $\alpha = 1 - N/N_o$, where $N = N_1 - N_2$ denotes the difference in populations of the ground and excited levels, and N_o is the medi density. Three conditions are treated:

1) $v < v_o$; in this case for any α a stationary regime of brightening wave propagation is established and the wave is of the traveling type.

2) $v = v_o$; in this case the stationary regime of wave motion is disturbed but at a definite time the desired α- value may be obtained at any point in the medium.

3) $v > v_o$; the maximum value for $\alpha_m = v_o/v$ is identified, which is obtained at the boundary $x = 0$; and in the total medium $\alpha < \alpha_m$ at any time. As $t \rightarrow \infty$, a fixed profile of the brightening medium level is established, i.e. the brightening wave becomes a standing wave. This phenomenon is similar to the propagation of a strong discharge in gas.

Kutateladze, S. S., and D. I. Avliani. Light propagation through a turbulent liquid. DAN SSSR, v. 206, no. 2, 1972, 311-312.

Theoretical factors affecting light propagation through a turbulent liquid are briefly analyzed. When pulsations of the refractive index n', generated by pulsations in density ρ' of a turbulent liquid flow, satisfy the condition n' << n, the mean-square pulsations of the refractive index differ from zero, and the isothermal flow can be expressed as $\sqrt{\overline{n'n'}} \approx n(n^2 - 1) \frac{d\rho}{dp} u \sqrt{\overline{u'u'}}$. It follows that the mean-square pulsation has a Mach number order of $M^2 = \frac{d\rho}{dp} \bar{u}^2$. The above averaging accounts for the fact that the time of light propagation through a normal turbulent medium is considerably shorter than the characteristic time of occurrence of local turbulent inhomogeneities. The refractive index increase in a turbulent medium is of the order $\Delta n_r \approx \sqrt{\overline{n'n'}}$. This increase is related to the beam attenuation factor, which is due to collision frequencies with small-scale pulsations of turbulent liquid density.

Experimental tests were conducted by interferometer methods to establish the dependence of light scattering of turbulent pulsations in a medium on physical properties and hydrodynamic parameters. Results quantitatively and qualitatively agreed with the theoretical formulas.

Sattarov, D. K., G. Ya. Konayeva, I. P. Gryaznova, and T. D. Kul'da. Light transmission of separate flux components emitted from a fiber-optics element. OiS, v. 33, no. 1, 1972, 159-164.

A method is suggested for measuring light transmission of effective and idle flux components from a fiber-optics element. The measureme scheme is shown in Fig. 1. The experiment consisted primarily in the

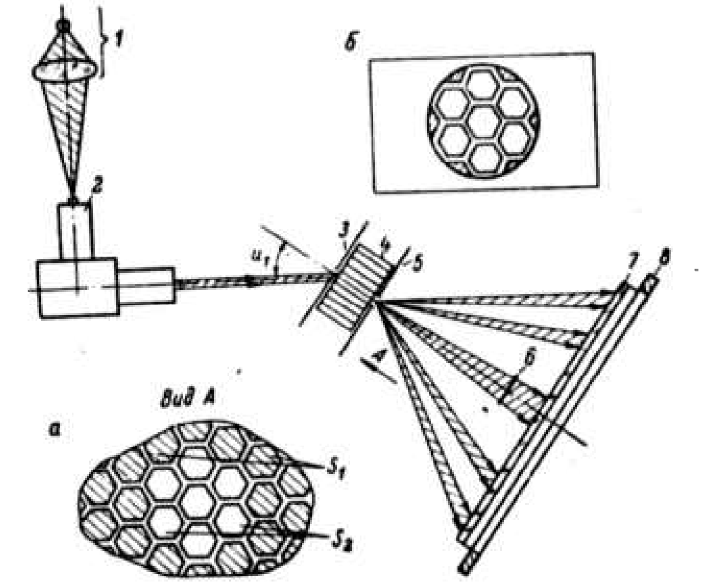

Fig. 1. Measuring method for separate flux components emitted from a fiber optics element. 1- illuminator; 2- monochromator; 3, 5- diaphragms; 4- fiber optics element; 6- slide; 7- milky glass; 8- photoelement. a, b- outlet face of fiber optics element with (b) and without (a) diaphragm.

measurement of the light transmission coefficient τ_ρ of the effective flux Φ_ρ the fractional flux Φ emitted from the fiber optics element, and coefficients of the idle components Φ_B^c, Φ_B^i, Φ_i^i, and Φ_i^c of emergent flux. The total light transmission coefficient is given by:

$$\tau = \frac{\Phi}{\Phi_0} = \frac{\Phi_{п} + \Phi_{в}^{п} + \Phi_{в}^{с} + \Phi_{к}^{п} + \Phi_{к}^{с}}{\Phi_0} \qquad (1)$$

where, Φ_o - total flux falling on the inlet face of the fiber optics element, Φ_B - extra-aperture flux, Φ_i - shell flux.

Tests were performed on a 28 mm diameter parallel fiber-layer specimen, using strands of 4, 50, and 100 mm and an 0.7 space factor. The nominal numerical aperture of the light guides was sin $U_0 = 0.54$. Measurements were taken for five angle values U_1 of an incident beam on a fiber optics element input face: 0, 20°; $32^\circ 15'$, 40° and $90^\circ - U_0 = 58^\circ$. Results are tabulated and curves are plotted for the total optical transmission coefficient, τ, and coefficients of individual components as functions of the angle U_1 of the incident beam (Fig. 2). It is seen from the figure that the ratio

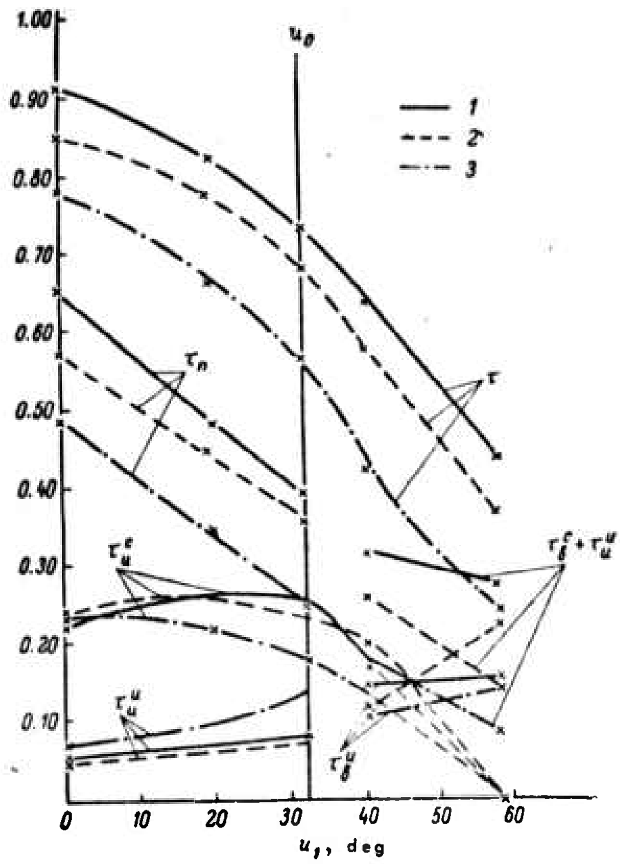

Fig. 2. Relationship of the total light transmission coefficient and coefficients of individual emission components to the angle U_1.

1- fiber optics element length 4 mm; 2- 50 mm, and 3- 100 mm.

τ_p/τ decreases with length and equals 0.71, 0.67, and 0.61 for $U_1 = 0$, and 0.54, 0.52, and 0.44 for $U_1 = 32^o$ for specimens with strand axis lengths of 4, 50, and 100 mm, respectively. Test results show that the optical transmission coefficient could be improved as follows:

1) increasing the numerical aperture of light guides to unity or higher, which eliminates the extra-aperture components Φ^c_B, Φ^i_B and the flux Φ^c_i, leaving only the components Φ_p and Φ^i_i;

2) using a semi-transparent light-insulating shell to attenuate the flux Φ^i_i, and

3) using light guides with the minimum feasible light-insulating shell thickness.

These conclusions were experimentally verified at a nominal numerical aperture $A_o > 1$ and space factor 0.7 and using semitransparent light insulating shells. Results were: $\tau = 0.66$, $\tau_p = 0.61$, $\tau^i_i = 0.05$, while calculated results for transparent shells taking Fresnel losses into account were: $\tau^i_i = 0.08$, and $\tau_p = 0.58$.

Stasenko, A. L. <u>Discharge of gas with solid particles into a vacuum.</u> I-FZh, v. 22, no. 3, 1972, 511-513.

A supersonic gas flow source is analyzed under the assumption that the flow expands greatly and contains entrapped solid and liquid particles interacting with gas. Such flows occur in comet heads.

Theoretical and experimental data were examined to obtain a relationship between the radius of transition from a continuous to collisionless medium and the corresponding mean free path ℓ (in a comoving coordinate system in a gas). Figure 1 shows radii of transition for rigid $\omega = 1/2$ and Maxwellian $\omega = 1$ molecules as functions of the inverse Knudsen number $Kn_*^{-1} = r_* / l_*$ on the sonic surface of a spherical source for various specific heat ratios $\varkappa$. Lines for the constant Mach number M = 10 are also shown. The comet core is represented by r_*; r_r stands for the radius value when the difference between macroscopic velocities in the core center and on the surface is comparable to the mean thermal velocity of the molecule.

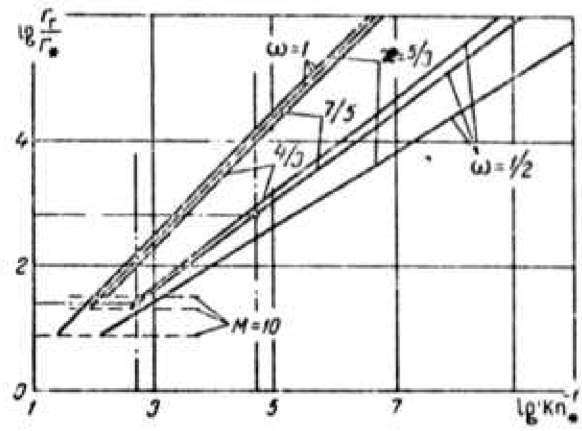

Fig. 1. Radius of continuous into collisionless flow versus Knudsen number on a supersonic sphere surface.

B. Recent Selections

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8. SOURCE ABBREVIATIONS

AiT	-	Avtomatika i telemekhanika
APP	-	Acta physica polonica
DAN ArmSSR	-	Akademiya nauk Armyanskoy SSR. Doklady
DAN AzSSR	-	Akademiya nauk Azerbaydzhanskoy SSR. Doklady
DAN BSSR	-	Akademiya nauk Belorusskoy SSR. Doklady
DAN SSSR	-	Akademiya nauk SSSR. Doklady
DAN TadSSR	-	Akademiya nauk Tadzhikskoy SSR. Doklady
DAN UkrSSR	-	Akademiya nauk Ukrainskoy SSR. Dopovidi
DAN UzbSSR	-	Akademiya nauk Uzbekskoy SSR. Doklady
DBAN	-	Bulgarska akademiya na naukite. Doklady
EOM	-	Elektronnaya obrabotka materialov
FAiO	-	Akademiya nauk SSSR. Izvestiya. Fizika atmosfery i okeana
FGiV	-	Fizika goreniya i vzryva
FiKhOM	-	Fizika i khimiya obrabotka materialov
F-KhMM	-	Fiziko-khimicheskaya mekhanika materialov
FMiM	-	Fizika metallov i metallovedeniye
FTP	-	Fizika i tekhnika poluprovodnikov
FTT	-	Fizika tverdogo tela
FZh	-	Fiziologicheskiy zhurnal
GiA	-	Geomagnetizm i aeronomiya
GiK	-	Geodeziya i kartografiya
IAN Arm	-	Akademiya nauk Armyanskoy SSR. Izvestiya. Fizika
IAN Az	-	Akademiya nauk Azerbaydzhanskoy SSR. Izvestiya. Seriya fiziko-tekhnicheskikh i matematicheskikh nauk

IAN B	-	Akademiya nauk Belorusskoy SSR. Izvestiya. Seriya fiziko-matematicheskikh nauk
IAN Biol	-	Akademiya nauk SSSR. Izvestiya. Seriya biologicheskaya
IAN Energ	-	Akademiya nauk SSSR. Izvestiya. Energetika i transport
IAN Est	-	Akademiya nauk Estonskoy SSR. Izvestiya. Fizika matematika
IAN Fiz	-	Akademiya nauk SSSR. Izvestiya. Seriya fizicheskaya
IAN Fizika zemli	-	Akademiya nauk SSSR. Izvestiya. Fizika zemli
IAN Kh	-	Akademiya nauk SSSR. Izvestiya. Seriya khimicheskaya
IAN Lat	-	Akademiya nauk Latviyskoy SSR. Izvestiya
IAN Met	-	Akademiya nauk SSSR. Izvestiya. Metally
IAN Mold	-	Akademiya nauk Moldavskoy SSR. Izvestiya. Seriya fiziko-tekhnicheskikh i matematicheskikh nauk
IAN SO SSSR	-	Akademiya nauk SSSR. Sibirskoye otdeleniye. Izvestiya
IAN Tadzh	-	Akademiya nauk Tadzhiksoy SSR. Izvestiya. Otdeleniye fiziko-matematicheskikh i geologo-khimicheskikh nauk
IAN TK	-	Akademiya nauk SSSR. Izvestiya. Tekhnicheskaya kibernetika
IAN Turk	-	Akademiya nauk Turkmenskoy SSR. Izvestiya. Seriya fiziko-tekhnicheskikh, khimicheskikh, i geologicheskikh nauk
IAN Uzb	-	Akademiya nauk Uzbekskoy SSR. Izvestiya. Seriya fiziko-matematicheskikh nauk
IBAN	-	Bulgarska akademiya na naukite. Fizicheski institut. Izvestiya na fizicheskaya institut s ANEB
I-FZh	-	Inzhenerno-fizicheskiy zhurnal

IiR	-	Izobretatel' i ratsionalizator
ILEI	-	Leningradskiy elektrotekhnicheskiy institut. Izvestiya
IT	-	Izmeritel'naya tekhnika
IVUZ Avia	-	Izvestiya vysshikh uchebnykh zavedeniy. Aviatsionnaya tekhnika
IVUZ Cher	-	Izvestiya vysshikh uchebnykh zavedeniy. Chernaya metallurgiya
IVUZ Energ	-	Izvestiya vysshikh uchebnykh zavedeniy. Energetika
IVUZ Fiz	-	Izvestiya vysshikh uchebnykh zavedeniy. Fizika
IVUZ Geod	-	Izvestiya vysshikh uchebnykh zavedeniy. Geodeziya i aerofotos"yemka
IVUZ Geol	-	Izvestiya vysshikh uchebnykh zavedeniy. Geologiya i razvedka
IVUZ Gorn	-	Izvestiya vysshikh uchebnykh zavedeniy. Gornyy zhurnal
IVUZ Mash	-	Izvestiya vysshikh uchebnykh zavedeniy. Mashinostroyeniye
IVUZ Priboro	-	Izvestiya vysshikh uchebnykh zavedeniy. Priborostroyeniye
IVUZ Radioelektr	-	Izvestiya vysshikh uchebnykh zavedeniy. Radioelektronika
IVUZ Radiofiz	-	Izvestiya vysshikh uchebnykh zavedeniy. Radiofizika
IVUZ Stroi	-	Izvestiya vysshikh uchebnykh zavedeniy. Stroitel'stvo i arkhitektura
KhVE	-	Khimiya vysokikh energiy
KiK	-	Kinetika i kataliz
KL	-	Knizhnaya letopis'
Kristall	-	Kristallografiya
KSpF	-	Kratkiye soobshcheniya po fizike

LZhS	-	Letopis' zhurnal'nykh statey
MiTOM	-	Metallovedeniye i termicheskaya obrabotka materialov
MP	-	Mekhanika polimerov
MTT	-	Akademiya nauk SSSR. Izvestiya. Mekhanika tverdogo tela
MZhiG	-	Akademiya nauk SSSR. Izvestiya. Mekhanika zhidkosti i gaza
NK	-	Novyye knigi
NM	-	Akademiya nauk SSSR. Izvestiya. Neorganicheskiye materialy
NTO SSSR	-	Nauchno-tekhnicheskiye obshchestva SSSR
OiS	-	Optika i spektroskopiya
OMP	-	Optiko-mekhanicheskaya promyshlennost'
Otkr izobr	-	Otkrytiya, izobreteniya, promyshlennyye obraztsy, tovarnyye znaki
PF	-	Postepy fizyki
Phys abs	-	Physics abstracts
PM	-	Prikladnaya mekhanika
PMM	-	Prikladnaya matematika i mekhanika
PSS	-	Physica status solidi
PSU	-	Pribory i sistemy upravleniya
PTE	-	Pribory i tekhnika eksperimenta
Radiotekh	-	Radiotekhnika
RiE	-	Radiotekhnika i elektronika
RZhAvtom	-	Referativnyy zhurnal. Avtomatika, telemekhanika i vychislitel'naya tekhnika
RZhElektr	-	Referativnyy zhurnal. Elektronika i yeye primeneniye

RZhF	-	Referativnyy zhurnal. Fizika
RZhFoto	-	Referativnyy zhurnal. Fotokinotekhnika
RZhGeod	-	Referativnyy zhurnal. Geodeziya i aeros"-yemka
RZhGeofiz	-	Referativnyy zhurnal. Geofizika
RZhInf	-	Referativnyy zhurnal. Informatics
RZhKh	-	Referativnyy zhurnal. Khimiya
RZhMekh	-	Referativnyy zhurnal. Mekhanika
RZhMetrolog	-	Referativnyy zhurnal. Metrologiya i izmeritel'naya tekhnika
RZhRadiot	-	Referativnyy zhurnal. Radiotekhnika
SovSciRev	-	Soviet science review
TiEKh	-	Teoreticheskaya i eksperimental'naya khimiya
TKiT	-	Tekhnika kino i televideniya
TMF	-	Teoreticheskaya i matematicheskaya fizika
TVT	-	Teplofizika vysokikh temperatur
UFN	-	Uspekhi fizicheskikh nauk
UFZh	-	Ukrainskiy fizicheskiy zhurnal
UMS	-	Ustalost' metallov i splavov
UNF	-	Uspekhi nauchnoy fotografii
VAN	-	Akademiya nauk SSSR. Vestnik
VAN BSSR	-	Akademiya nauk Belorusskoy SSR. Vestnik
VAN KazSSR	-	Akademiya nauk Kazakhskoy SSR. Vestnik
VBU	-	Belorusskiy universitet. Vestnik
VNDKh SSSR	-	VNDKh SSSR. Informatsionnyy byulleten'
VLU	-	Leningradskiy universitet. Vestnik. Fizika, khimiya
VMU	-	Moskovskiy universitet. Vestnik. Seriya fizika, astronomiya

ZhETF	-	Zhurnal eksperimental'noy i teoreticheskoy fiziki
ZhETF P	-	Pis'ma v Zhurnal eksperimental'noy i teoreticheskoy fiziki
ZhFKh	-	Zhurnal fizicheskoy khimii
ZhNiPFiK	-	Zhurnal nauchnoy i prikladnoy fotografii i kinematografii
ZhNKh	-	Zhurnal neorganicheskoy khimii
ZhPK	-	Zhurnal prikladnoy khimii
ZhPMTF	-	Zhurnal prikladnoy mekhaniki i tekhnicheskoy fiziki
ZhPS	-	Zhurnal prikladnoy spektroskopii
ZhTF	-	Zhurnal tekhnicheskoy fiziki
ZhVMMF	-	Zhurnal vychislitel'noy matematiki i matematicheskoy fiziki
ZL	-	Zavodskaya laboratoriya

9. AUTHOR INDEX